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THE TEACHING OF PHYSIOLOGY IN THE COMMON SCHOOLS.*

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There is not today a more important question for educators to seriously consider than the one here presented for discussion. I take pleasure in opening the discussion in Chicago, and feel certain that we shall all enter upon it with minds open to conviction on all points. We are all in search of that happy and safe middle ground of truth and justice which history has shown invariably lies between the positions occupied by the partisans in a controversy.

In my discussion of the subject as I have stated it I wish to formulate a few general principles or theses which may be discussed individually. The acceptance or rejection of each thesis in its order will bring us progressively nearer and nearer to a definitely formulated policy, acceptable to members of our organization.

I. NATURAL OBJECTS AND NATURAL PHENOMENA SHOULD BE STUDIED IN ALL PUBLIC SCHOOLS.

All leading educators accord to the study of nature a prominent place in their systems of education. These systems may differ from each other widely in detail, but they possess one feature in common, and that is a provision for the study of nature.

*Paper read at a meeting of the Central Association of Science and Mathematics Teachers held Friday evening, November 27, 1903.

Whether the pupil is a kindergarten child or a high school youth he is invariably interested in the study of natural objects. The discipline afforded the pupil is most natural and profitable. In the study of the object the senses are exercised and the attention cultivated; the formation of percepts and concepts involves the activity of memory and of reason. The description of objects gives opportunity to cultivate language, both oral and written. Incident to this expression of ideas the pupils get their drill in orthography, etymology, syntax, punctuation, writing, reading, perhaps, also more or less collateral work in arithmetic, geography, history and literature. The expression of ideas through diagrams and drawings should also be emphasized.

Thus a trip to the field, the lake shore, the swamp, the pasture, the woods, or to a flowing stream may provide material for a fortnight of most profitable and inspiring work.

It is understood, of course, that all the nature work done in the grades should seem to be more or less spontaneous on the part of the pupils. The season, the weather, some astronomical phenomenon of unusual interest may furnish material for a week's work. The teacher takes the material at hand and makes the most of it.

This method of presenting the natural objects which form the material of the natural sciences precludes the possibility of a systematic presentation of the facts and principles of biology, physics, chemistry, geology, or astronomy. In the grades there should be no attempt to separate out and systematize the facts and principles. Up to the age of fourteen the whole field of nature should be carefully and minutely observed, simple experiments performed, and the results of all observations carefully noted and used as subject matter for a large part of the school work. In passing it may be remarked that from the study of nature and natural phenomena to the study of the industries, beginning with agriculture and following with grazing, mining, lumbering, manufacturing and commerce, there is an easy and natural transition, and that the two fields of work—study of nature and study of human industries—may well occupy a very large part of the time of the pupil up to the age of fourteen.

In the high school the study of nature is no less important than it is in the grammar schools. A smaller proportion of time should be devoted to it, and here for the first time the facts and laws of natural phenomena should be systematically presented in the form of *sciences*. The high school curriculum should provide such science courses as these: Biology, physics, chemistry, geology, astronomy, and perhaps other sciences, all carefully limited in breadth and depth to the mental attainments and capacity of the average pupil of the high school age.

II. THE STUDY OF LIVING FORMS AND OF LIFE PHENOMENA MAKE AN IMPORTANT AND ESSENTIAL PART OF NATURE STUDY.

Having set forth some of the pedagogic possibilities of nature study in the grammar schools and the relation of the work to the natural sciences as presented in the well-equipped high school of today, it now becomes necessary for me to show the relation of biology to natural science in this general system of education.

Any teacher in the grades will bear testimony to the abiding interest which pupils uniformly take in living forms and life phenomena. From the day when the pupil is allowed to bring his pet cat or dog to the kindergarten to serve for the subject of a lesson to the time when he is allowed to make a careful study of one plant from the seed which he buries in the ground, to the gathering of the next generation of seed, the teacher finds living forms and life phenomena an open sesame to the pupils' attention and interest.

Some of the life forms and phenomena which may form legitimate and profitable subjects for study between the sixth and fourteenth year may be enumerated: General form, life history, and habits of domestic animals, beginning with those most familiar to the pupils; general form, life history and habits of cultivated plants, choosing those most familiar to the pupils. In a similar way animals and plants not domesticated or cultivated should be studied as material and opportunity present.

In the presentation of these objects of study to children and youths, it is my observation that the interest is far more keenly

awakened by the study of what an animal does than by the study of its structure. We all know how interesting to a boy or girl is a mill *in operation;* they like "to see the wheels go round."

So in the study of living nature the questions which the pupils ask make it evident that they are far more interested in the functions of the various parts of an animal than in the construction of the animal, i. e., *they are more interested in physiology than in morphology.*

III. THE PHYSIOLOGY OF LIVING FORMS IS THE MOST INTERESTING AND PROFITABLE FIELD OF BIOLOGIC STUDY.

The facts and principles which make up the sum of our knowledge of living forms—our science of biology—may be classified under two general heads, comprising what we know of form or structure (morphology) and what we know of function (physiology).

As already set forth above, the interest of the pupil is far more easily aroused in a question of action (physiology) than in a question of structure (morphology).

The instinctive interest of the pupil should be the teacher's guide.

In the other fields of nature study the pupil's interest in the action—the *phenomenon*—rather than in the structure or physical qualities of the natural objects involved have led teachers to dwell with especial emphasis upon the action rather than upon the structure.

In the light of this experience teachers may proceed with full confidence that in emphasizing the actions (functions) of living objects they are in harmony with the highest authorities in methods of presenting natural science.

Accepting the above definition and classification of physiology —which is, by the way, the only scientific and tenable definition of physiology in its general sense—it then becomes evident that in the model school of today physiology is already taught as an essential part of nature study.

It may be remarked in passing that this is the only legiti-

mate way to introduce the facts and principles of physiology in any rational and pedagogically scientific system of education.

But physiology so far as discussed up to the present time belongs to what is known to physiologists as *general physiology*. The field of general physiology—*i. e.*, the activities, habits, etc., of plants and animals—should always be presented to pupils before they take up the consideration of any of the more specialized fields of physiology.

Incident to the study of living forms and their actions, the pupil will discover some day that his body possesses many structures similar to those possessed by the animals which he is studying. His pet dog possesses body, legs, head, eyes, ears, nose, mouth, tongue, teeth. The dog runs, walks and lies down; he sees, hears, smells and feels; he gets hungry and thirsty; he eats and drinks. These points of likeness appeal to very young children. Their questions must be answered, and their interest satisfied. When this subject is launched by some bright and observing pupil, then is the teacher's golden opportunity. Then she can afford to drop all other study for a week or a month and study MAN. What more interesting and inspiring subject?

This opportunity may present itself in the third, fourth or fifth grades for the first time. In either case the teacher must be cognizant of the limitations of her pupils and not lead them beyond their depth.

Legitimate subjects of study would be: What does man eat? Where and how is it produced? How is it prepared? Why does man eat? How does the body use the food? What happens to the food in the mouth, the stomach, the intestines? How is the food (digested food) distributed to the parts of the body where it is needed? Why does man need to breathe? What kind of air should one breathe?

These and many other questions of this scope can be taken up with pupils of the fifth to the eighth grade—spending much or little time each year or season, according to the *pedagogic indications* at the time. The trained teacher will appreciate what I mean by *pedagogic indications*. A cramming or forcing process

is never *indicated* pedagogically. If the pupils are not interested in a subject, no matter whether the subject is plant life, water action, wind action, digestion, sentence construction, cotton growing, word structure, cattle raising, or punctuation, *when the interest flags change the subject.*

IV. THE PHYSIOLOGY OF MAN IS THE MOST INTERESTING AND IMPORTANT FIELD OF PHYSIOLOGY; AND NO OUTLINE OF EDUCATION WHICH OMITS IT CAN BE ACCORDED A PLACE AMONG THE MODERN SYSTEMS.

This thesis is presented without argument. If the writer has struck a sympathetic chord it will be accepted without argument.

V. RULES OF HYGIENE FORM LEGITIMATE COROLLARIES TO PRINCIPLES OF PHYSIOLOGY AND SHOULD BE PRESENTED IN THEIR LOGICAL RELATIONS.

When one is discussing mastication and the use of the teeth, the necessity for thorough mastication and insalivation can hardly be omitted from the discussion. The care of the teeth seems to be a most natural topic to discuss incident to the study of their use. There seems to be no tenable argument against allowing the discussion of rules of hygiene in connection with each function studied. On the other hand, a failure to discuss these rules and to emphasize their importance would be an omission of a duty. The pupil's mind is prepared for it; a rule for hygienic living based upon the solid foundations of demonstrated science can not be counter to any religious system, nor can it be itself interpreted as a religious system. Then let hygiene be taught in the common schools.

How much hygiene shall be taught? So much and only so much as is logically correlated to the physiology given. These rules of hygiene should be the formulated conclusions, based upon physiologic facts and principles.

VI. THE PHYSIOLOGIC ACTION OF THINGS IN SUCH COMMON USE AS CHEWING GUM, TEA, COFFEE, TOBACCO AND ALCOHOL SHOULD BE DISCUSSED AS FREELY AND AS FULLY AS THE ACTION OF RICE, EGGS, BUTTER AND WATER.

No teacher—no scientific man—will have the temerity to oppose this thesis. If I were asked whether I should give more time to the consideration of these deleterious substances than to the consideration of wholesome foods and beverages, I should unhesitatingly say, *No!* I should emphasize particularly the value of the wholesome foods and beverages, and I should lead pupils to discover the folly of the use of the unwholesome ones.

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In closing, I wish to call the attention of my fellow teachers to a matter which I believe to be of paramount importance in this connection.

If we are to follow the paths being blazed by such pioneers as Dr. Dewey in his "School of Education" we must have more thoroughly-equipped teachers in our graded schools. The methods which I have briefly outlined are those now used in the model schools of Chicago University, Columbia University (Teachers' College), and a few similar schools of education. The teachers employed in these model schools have the broadest training. They are thoroughly equipped in chemistry, physics and biology, including physiology.

Our public schools can not introduce an efficient and thoroughly successful system of nature study until the teachers can enter upon their work after a thorough training in natural science. I make a strong plea for the introduction of thorough courses in the experimental natural sciences, including physiology, as a part of the biologic training. We should combine our influences toward the attainment of this much-to-be-desired end. Teachers can not effectively teach physiology without training in experimental physiology, any more than they can teach physics or chemistry without experimental training.

WHAT TRAINING IN PHYSIOLOGY AND HYGIENE MAY WE REASONABLY EXPECT OF THE PUBLIC SCHOOLS?*

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Physiology and hygiene were originally introduced into the public schools "for the express purpose of affording information concerning the structure and functions of the human body, being expected thereby to contribute to the preservation and promotion of health; and they have kept their place, in spite of serious shortcomings, as a concession to the practical importance of sound ideas concerning health and disease."

Physiology and hygiene, unlike most of the other subjects in our schools, are rarely taken into account in promoting pupils. "They are seldom included in the list of requirements for admission to colleges or technical schools, and never in those for medical schools. They are not often much considered in educational congresses. And yet it is doubtful whether any subject in the whole curriculum of the public schools is of greater intrinsic importance as a preparation for life, or is capable of affecting more profoundly the whole mental attitude of men and women toward an enduring and well organized civilization."

Twenty-five years ago physiology was a new science, a mere adjunct to anatomy. Today it is established as an independent science, with its own professors, investigators, associations and other evidences of solidity.

Hygiene has made even greater progress within this time; in the management of infectious diseases, the disposal of sewage, the improvement of public water supply, the laying of sanitary pavements, and the disposal of dust and garbage. Boards of health carry on sanitary research, supervise the medical inspection of schools, isolate cases of infectious disease, provide for the disinfection of clothing and premises, enforce vaccination, and vacate unwholesome dwellings. Our school authorities are promoting

*Abstract of paper read May 16, 1903, before the American Social Science Association.

hygiene by providing playgrounds and better ventilated school buildings, and by greater attention to the position, sight and hearing of pupils. Moreover, the home—its site, drainage, wall papers, ventilation, cookery—and the individual body—its exercise, fatigue, work, rest, play, clothing, bathing, hunger, thirst, sleep, growth and old age—"all these are dealt with today, not superficially and by tradition or experience alone, as formerly, but also by experiment. Physiology and hygiene have become experimental sciences, and have thus taken on a new and higher value."

Such is the present status of these sciences that the object of public school training in them must still be primarily practical and technical; viz., "a sound preparation for the right conduct of physical life. For although it is one argument for increasing the efficiency of instruction in these subjects that they give information on matters of great human interest, and that, when rightly taught, they are of high educational value, still the primary purpose of teaching them is not to give information nor mental discipline, but because their subject matter is of immediate and enduring importance in determining and promoting the right conduct of the physical life, and especially the preservation and promotion of health. Their value is special rather than general, practical rather than cultural, technical rather than disciplinary."

While physiology and hygiene have, in exceptional cases, had a good influence in the school curriculum, they have not always justified their place; they have not, on the whole, accomplished what was originally expected of them. They are too often looked upon by school authorities as an unavoidable necessity, and by teachers and pupils as a bore. Competent educators have favored dropping them altogether from the course. This unfortunate state of affairs is due largely to the fact that the primary purpose of these subjects in the curriculum has been neglected or forgotten. From the first, the details of gross and minute anatomy have formed the major part of the work in physiology and hygiene in the schools. Function in health and disease has had an insignificant place because it has been so poorly understood. The teaching in the public schools has lagged behind the advance of medical and hygienic science. Today it is inexcusably behind the times. "We now have

facts which any one can teach and which should be made known as a preparation for the proper conduct of life; and it is these facts which should form the main part of the teaching." Anatomy should be restricted "to the minimum amount needed to give a clear conception of the general structure of the body as a mechanism and of the normal working of that mechanism. . . . . An arid osteology is a poor introduction to the study of modern hygiene, nor is it calculated to arouse a compelling interest in the subject."

As to physiology, its educational value is much greater than that of pure anatomy. It is a good teaching subject, because it deals with a machine in which most of us are naturally interested. It has also the highest philosophic value; it imparts that lesson so well expressed in Huxley's statement, that "the distinctive feature of modern as contrasted with ancient physiology" is "the fundamental conception of the living body as a physical mechanism." The use and abuse of patent medicines and the frequent negligence in the care of the body prove that most people have not incorporated this fact in their philosophy of living.

"We have urged that anatomy has no place in the public school curriculum, except as it is necessary to the understanding of the problems of physiology and hygiene; and we shall see it cut down to the minimum needed for this purpose without the slightest regret." Fortunately, however, the course in physiology may be made strictly subservient to personal hygiene without sacrificing its philosophical value. For "the physiology which is most useful in understanding the problems of personal hygiene is almost exactly the same body of facts which has the greatest philosophic value, and the method of presenting them is the same for the one purpose as for the other."

The course in physiology should teach the outlines of muscular contraction, nervous activity, circulation, nutrition, temperature-regulation—all expressed as far as possible in terms of physics and chemistry, and without needless details. "Again, physiology should not be made primarily or even to any large extent in public schools a means of laboratory training. Such training can be had more readily and more advantageously in chemistry and physics. To attempt to give the same laboratory training in physiology

as in these would inevitably be to consume that time which is urgently needed for hygiene. The fundamental facts of physiology can be demonstrated and enforced in the laboratory, even in common schools, without much difficulty, and we would not for a moment depreciate the value or the necessity of a certain amount of this kind of instruction; but the use of the laboratory (always time-consuming) must not be allowed to distract attention from the true aim of this work or to interfere with its complete realization."

The course in physiology should "impart enough facts of structure and function to furnish a solid basis for sound training in hygiene, and to give meanwhile an abiding sense of the material composition and mechanical character of the human body and its environment and operation. With so much of preparation it becomes easy to pass on to a practical consideration of health and disease, the means of promoting the former and of avoiding the latter."

The strictly hygienic parts of the subject begins with personal hygiene—"the proper regulation of activities of individual life—muscular work, mental activity, feeding, the protection against colds and other inflammations, the care of the body by bathing and clothing and the like. These should not be given in short paragraphs which, like afterthoughts, conclude the chapters in anatomy or physiology, but should be separately and fully treated for their own sake and from the standpoint of the organism as a whole rather than from that of special organs. These are subjects about which every one needs real and true information, and sooner or later seeks it. Shall such information be obtained from the public schools or sought unwisely in the brazen advertisements of magazine originators of new systems of physical training, or in the rash and not disinterested advice of advocates of new breakfast foods?"

The hygiene of the family, of the community, of states and of nations each have a place in our preparation for sound private and public life, and, therefore, in the public school, where the great majority of our householders, housekeepers and heads of families receive all their education. "The principles underlying

household or domestic hygiene and sanitation, therefore, claim some consideration at their hands. These would include such questions as the proper site of the house, the value of fireplaces as ventilators, the importance of wall papers free from arsenic, the advantages of bare floors and simple rugs as compared with carpets difficult to clean, the importance of a pure and abundant water supply, the desirability of prompt removal of wastes by drainage and by such other devices for rural communities as may be made most sanitary under the circumstances, the dangers of damp cellars with the reasons why cellar dwellings have so often been prohibited by law, the dangers of illuminating gas, especially the modern so-called 'water gas,' the need of careful consideration and frequent inspection of gas fixtures to avoid small but dangerous leaks, and other similar matters bearing directly or indirectly upon the welfare and sanitary condition of the home. Here might well be told the truth in regard to the advantages and disadvantages of cesspools and sewers and leaky or otherwise defective plumbing.

"Place should also be found, and might easily be made by the sacrifice of some osteology and histology, for a brief consideration of the health of communities, such as thickly settled neighborhoods, growing towns or cities: of the dangers attending impure water supplies and defective sewerage systems, and the importance of methods for the sanitary removal and disposition of garbage, rubbish and the other wastes of life. Something might well be said regarding the need of proper municipal supervision of all these matters as the essential of a rational municipal sanitation and of the sanitary value of good public service. Here might also be taken up the advantages and the cost of municipal parks, playgrounds and gymnasia; of public lavatories, water-closets and washhouses; of smoke abatement and noise suppression; something regarding clean streets and the thoughtless scattering of papers, banana skins and the like rubbish, which necessitates a costly scavenging; something regarding pure ice, and especially pure milk—problems in the solution of which all classes of the community must eventually take an active interest and participation, if reform is to come.

"And, finally, room should be found for a brief explanation of quarantine, its advantages and disadvantages; the isolation of cases of infectious disease, and the reason why it is so essential, though so inconvenient; the necessity for public hospitals for contagious diseases, and for municipal or state sanatoria for tuberculosis; the fundamental problems of international hygiene; food inspection, such as that conducted by the federal government for trichinosis in pork to be exported to foreign countries; diseased meat and other problems calling for intelligent coöperation of the citizens in national and international hygiene." * * * "We have, of course, to meet the important objection which will be urged against our point of view, namely, that, desirable as all these things may be, the time available is too short for proper dealing with them. This, however, we deny. Time enough to do all these things, and to do them well, either is now or lately has been found in the public schools in the various courses for instruction in physiology and hygiene. It will be necessary, it is true, to revise and bring up to date our subject-matter and our methods of instruction. We must teach less about bone and sinew and more about muscle and nerve. We must teach less about anatomy and histology and more about the germ theory of disease, about polluted water and polluted milk. We must simplify every statement and eliminate everything unimportant. We must not seek to make of physiology a training in the precision of measurements, or in scientific method, or in anatomy, or physiological chemistry. Some experiments must be made and demonstrations must abound; but we must keep steadily in view the practical object for which chiefly time is and long has been dedicated to physiology and hygiene—namely, the rational conduct of physical life.

"Above all, we must insist upon relief from the incubus of 'scientific temperance' instruction, so called, which has too long rested upon the teaching of physiology and hygiene, winding its tentacles about it, octopus-like, sapping its strength and crushing out its usefulness. On this subject let us have no misunderstanding. The evil effects of the use of alcoholic drinks must be fully and clearly inculcated. The youth of America must be thoroughly informed of the insidious dangers which lurk about strong

drink. But, on the other hand, we must never forget that the public schools are no place for any propaganda and that the freedom of teaching must not be surrendered even to reformers.

"Whether we are pleased with the fact or not, modern life has become more strenuous. In order to achieve success the individual must do more in a given time. Hence the urgent importance of a personal hygiene which shall really guide him in the proper care of the body. Meantime the care of the public health has become one of the most important functions of government, and it will be increasingly important in the future. Its success in America must largely depend upon an enlightened citizenship to which it can look for support. We now teach history and economics and civics with some reference to the future life of the public school pupil as a citizen. Our teaching of hygiene should keep in view a similar end, and if this paper draws attention to the lamentable inadequacy of our present instruction for this purpose, our object in preparing it will have been largely accomplished."

So important a subject should be taught by teachers specially trained. But we rarely find such expert teachers in charge of these subjects as of languages, history, or mathematics. Often the least experienced teacher in the school has charge of physiology. All this must be changed in some way. The work might well be combined with the instruction in physical training. Both subjects would gain in effectiveness by this union. It would, indeed, require broader and better preparation on the part of our teachers of physical training; but this is an argument in its favor.

"There is certainly a widespread feeling that our present training in physiology and hygiene in the public schools is a failure; but signs are not lacking of a strong feeling among prominent educators that the subjects can and should rank in dignity and usefulness with languages, mathematics, physics, chemistry, biology, history, and civics. Physiologists have long protested against the domination and excess of 'temperance physiology.' Educators have complained of the bad pedagogical requirements often placed by law upon the teaching of the subject. We appeal to the members of the American Social Science Association to aid us in bring-

ing about reform, not as parties to either side of a dispute on questions of scientific fact about alcohol, nor from the standpoint of pedagogic theory and practice, but because the subject is one which profoundly affects social conditions and is closely related to a more intelligent individual and social American life."

F. W. B.

NATURE STUDY IN THE GRADES.*

BY LINCOLN M. RUTLEDGE.

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The child in our city school leads a life essentially artificial. Too often is his home an apartment house or flat; he has no yard; his only playground is a gymnasium, and he seeks to relieve the nervous strain under which he lives by turning to the theater or social functions for his recreation. This child is often anæmic, is selfish and irritable, and his interest in school work is largely perfunctory.

The country child coming in to the district school, while of sturdier frame than his city cousin, is too often not one whit better off. So many times patterning after his elders, he measures everything in life by the standard of dollars and cents and has only indifference or contempt for anything which does not possess a clearly defined utilitarian value.

Alas! How sad it is to think that so many of both classes reach years of maturity and yet are, as Whittier so truly says,

> "Blind to the beauty everywhere revealed,
> Treading the May flowers with regardless feet;
> For them the song sparrow and the bobolink
> Sang not, nor winds made music in the leaves;
> For them in vain October's holocaust
> Burned, gold and crimson over all the hills;
> The sacramental mystery of the woods."

*Read before the U. P. Michigan Educational Association, October 30.

How much of mensuration or history or grammatical construction do we expect our present pupils to remember fifteen years, say, from this time? Not very much, surely, and if we do, we are as certainly doomed to disappointment; but the nature study we gave them will, if it has been well presented, remain, and will have proved the foundation for a series of delightful observations and investigations that will continue through life. Oh, forever blessed is that teacher who gives to the child the golden key that unlocks the great sealed volume of Nature's mysteries and teaches him to read, if only in part, her never-ending story!

I have shown a sequence of topics for nature study in the grades which I have used for several years, either in whole or in part.

Taking up the other phase of the topic—some principles to be observed, and ends to be achieved—under the head of principles to be observed, I would say,

First—*Be very slow to tell the pupil anything he can find out for himself.* While our knowledge of things in general is necessarily largely second-hand, yet "helplessness is too often the direct product of too much help," and the child that digs the thing out by himself, makes his own observations and then draws his own conclusions aright, has become a real discoverer and is thrilled and uplifted with the joy of his achievement. Dont', *e. g.*, tell a child that the ox or cow in grazing grazes out from itself, while the horse in feeding grazes in toward itself; or that the cow, after lying down, gets up with the hind quarters first, while the horse gets up just the reverse of this—train him to use his eyes and to see these things for himself.

Second—*Be candid and straightforward with your pupils and be ready to say "I don't know."* Do this, if only in your own interest. They will surely find you out, and a candid admission of your lack of knowledge enables you to retain their respect. They will not forget and will be slow to forgive an attempt at deception. And remember that your "I don't know" of today may easily be "I know" tomorrow. Be an earnest student along this line, and impress your children with the fact that you are growing, and therefore can consistently expect growth of them.

Third—*Do not confound nature study with science.* The terms are not synonymous, and the teaching of the one is radically different from that of the other. Science is classified knowledge involving laboratory work, the microscope, higher mathematics, characteristic technical terms or a special nomenclature, etc. Nature study requires none of these. In your nature teaching seek rather first to be full of your subject, and then to make your simple but really scientific treatment of it attractive to the child's unscientific mind. It is not essential that he know that the feeler of a crayfish is an antenna or the gill plate of a brook trout is the operculum. It is not especially essential that he be able to indicate the plumule or the cotyledons of a bean plant, but what is of most vital importance is that in some way you inspire him with a love for investigation, that you awaken him to a keen appreciation for and interest in the wonders and mysteries about him on every hand.

With this very brief discussion of three principles to be observed, I will call your attention to a few ends to be achieved.

First—*Increased mental power.* No nature study worthy of the name can be long pursued without growth in observation, judgment, and the power to think clearly and continuously along one line for a considerable time. The value of this latter accomplishment to the child can hardly be overestimated.

Second—*Promotion of health.* While this work is carried on to a certain extent in the school, the work in the schoolroom is merely suggestive of the broader and better line of work which can and should be carried on in woods and fields. This means often tired muscles, keen appetite, and the joy and exhilaration that come to one where skies are blue and pastures green and the birds sing in the branches.

Third—*The awakening of the aesthetic nature.* Who among us will attempt to fathom all the avenues of pleasure that open to the child when he has been led to a genuine appreciation of the beautiful! And what a wealth of beauty all about him! Teach him to study sunrise and sunset; he probably never has seen the one nor closely watched the other.

Who will attempt to say all it may mean to the child if you

can inspire him to go forth while the stars are yet shining and when, as Edward Everett says: "Hands of unseen angels shift the scenery of the heavens, and slowly the mysteries of the night resolve themselves into the glories of the dawn."

Encourage him to study the ceaseless panorama of the clouds, moonlight effects, dew, frost and snow.

Fourth—*The development of the ethical nature.* What a complex problem does your school present to you! This child is impatient, that one selfish, another conceited, some lack determination and the indomitable will that conquers difficulties. Yet the woods and fields teach their helpful lesson to each of these if you will only take them out and have them "list to Nature's teaching."

The bonds of sympathy and good-fellowship established will help both pupil and teacher.

In the soul's best moments he will turn to you as confidant and friend and in no other way that I know can the problems of discipline be solved so satisfactorily.

These hours of reflection will surely lead the child to broader views of life, clearer convictions of duty, nobler conceptions of God.

But I am loath to close without a word as to what nature study will do for you, my fellow teachers. Much as it means to your children it means infinitely more to their instructor. The opening lines of Thanatopsis are ever true.

Remembering that "God made the country and man made the town," steal a frequent hour far from the haunts of men and there, with only your "kindred of the wild" as fellows, think out life's problems and fight your battles with self.

Forget your cares, recount your blessings, nobly resolve, and so walk on and on and on, until you can turn back tired but happy, wearing "the soul's calm sunshine and a smile at heart."

SOME SPECIAL PHASES OF PHYSICS TEACHING.*

Making courses of study has received great attention during the last few years; especially in secondary schools has there been much thought and discussion along this line. Science received new life and great impetus a few years ago. A great demand for the introduction of science came because of the value of the information which it had to give, but within the recent past science has apparently been losing ground. It does not seem to me that the reasons for this are far to seek. It is entirely superfluous for me in this presence to say that personally I place the educational value of science in secondary schools, especially physics, very high. But I have been sorry to see certain tendencies working against science teaching since the introduction of laboratory work, and it is to these difficulties that I wish to call your attention for a few moments this evening.

The first difficulty that I wish to mention is a misapprehension of the mission of physics teaching in high schools. It goes without saying that physics embraces an important branch of human knowledge. Because of this fact the majority of lay people and many teachers think that it must of necessity form a valuable branch of study. They entirely forget that because a subject gives valuable information is no necessary guarantee that its teaching will make an efficient instrument of education. Information, of course, must be given, but it is of more importance still that right and abiding interests be aroused, and that power be obtained, and that refinement and culture be realized. Where the patrons of a school, the members of a class, or the teacher, or all three of these, feel that the information to be obtained from a course in physics is its chief reason for its place in the schools, that subject will be taught in a weak and inefficient manner. It becomes a pouring-in process, a process of giving encyclopedic information and not of imparting living, vital power. I feel that here has been a serious drawback to the most advantageous teaching of physics, and for that reason some of the reaction already referred to has resulted.

A second obstacle is that many teachers of physics, and other

*Abstract of remarks by Superintendent D. L. Bardwell at meeting of the Physics Club of New York.

sciences too, not only in high schools but in colleges as well, are more intensely interested in the science itself than in that science as an instrument of education. Wherever and whenever this is true the teacher may make a great record as an investigator and lecturer, but he will, generally speaking, be a poor teacher, and his pupils will make but slow progress toward real and abiding education. I wish to urge that the attention be given not so much to the science as to the people who are being instructed in the science.

A third difficulty arises from a misapprehension, as I see it, of the true purpose of the laboratory in secondary schools. Much has been made of independent research, still more of quantitative results. As a matter of fact we all know that independent research is entirely beyond the reach of the high school pupil. He needs guidance in every step; he needs to be told what to do, how to do it, and what to look for; and he needs guidance in drawing correct conclusions. His interest in quantitative work, considered independently, is not great, nor to my mind is it particularly valuable for high school pupils; especially do I think so because of the fact that there is much wider field of better work realizing better results. The average high school boy cares less for obtaining the exact measurements of a block of wood as a block of wood than he does to accurately measure a block of wood in order that it may find a definite place and serve a definite end in a large piece of apparatus. In short, the quantitative to him becomes vital when he sees its results materializing before him. Here I think is a wide field as yet but slightly developed.

The fourth obstacle, and the last which I will mention, arises from the still crude condition of our work in the laboratories. We are seriously handicapped by the cumbersome process necessary in laboratory work. This will become more apparent by a contrast with the work in language and in mathematics; in those subjects the teacher with a minimum amount of time and effort can assign to his class for the work of the next day a large amount of definite preparation and can easily send them away feeling sure that they know what to do and how to do it. For the entire preparation of a lesson in language or mathematics the pupil is required to think continuously and consecutively; his problems materialize before him as his progress is made; the various portions of his tasks

become evident, and he solves each in its turn. During this entire preparation he is held to close consecutive thinking which leads to power; thus there is growth and advancement in real education. On the other hand, the teacher of physics must take much time to prepare his apparatus and possibly more time to instruct his pupils how to use it. During all of this time his pupils are using but half, or even less, of their attention or powers. When they reach the laboratory how frequently it is found that they have but partly understood the instructions already given and need careful watching from first to last. A serious danger arises in all this. Not only is much time consumed, but, what is far more serious, this time is not used to the best advantage by the pupils. They are not putting forth effort, and when they are not putting forth effort they are not acquiring power. Along this line there is need of much organized and united effort on the part of all teachers of physics.

I believe that at just this point there should be concerted action to overcome this serious obstacle. In my mind, unfortunate though it may be, it is not especially surprising that college authorities are slow to accept as equivalent to the same length of time given in mathematics or language, a year's course in physics.

We need to so adjust the work as to require closer, more consecutive effort on the parts of our pupils. In this connection I wish to suggest that keeping the eyes and the ears open, although highly important, is not in and of itself an acquirement of power. The condition of alertness is highly important, but that condition is simply an attitude receptive for obtaining power—it is not the power. The eyes and the ears and other avenues of knowledge must not only be opened, they must also be used, that the brain behind them may be in constant activity. It is not the open eye but the used eye and the active brain which give education.

I will simply add that in my judgment when conditions are right and the pupils use the avenues which lead to the brain, and the brain itself, as they can and should be used, there is no branch of study within the reach of high schools more productive of growth in mental power and of real education than physics.

SHOULD THE STUDENT BE DIRECTED TO EMPHASIZE ONE POINT ONLY IN EACH EXPERIMENT, OR SHOULD HE BE HELD RESPONSIBLE FOR ALL NATURALLY RELATED PHENOMENA?*

JOHN C. HESSLER,

Instructor in Chemistry, University of Chicago.

The question of the proper placing of the emphasis in experimental work has been discussed, in one form or another, during all the years in which laboratory practice has formed part of the curriculum of secondary schools and colleges. In spite of what was said by one of the speakers of the morning (Dr. Trelease) most of us still hold the belief that the student in the secondary school and in his first years in college should study, primarily, for the sake of mental training rather than for a knowledge of facts. In consequence of this belief, the emphasis in an experiment has come to be placed upon one salient idea arising out of the experiment rather than upon *all* the phenomena suggested by the experiment. This is true not only of elementary laboratory work, but also, to a great degree, of the laboratory work connected with a piece of investigation.

The method of selecting a certain point in an experiment and emphasizing it has at least *two* great advantages over the opposite method:

1. It concentrates the student's attention.

2. It concentrates the instructor's guidance. That the experimenter in science, like the student in other branches of knowledge, needs constantly to bring his mental activities to a *focus,* is obvious to everyone acquainted with scientific methods of work. The wide-awake mind has so many impressions brought to it by even simple phenomena that all sorts of devices have to be used to bring it to and hold it upon a few things at a time. Hence the advantage of good mental training. The untrained mind lacks not only the knowledge of true principles required for scrutinizing

*Paper presented before the Chemistry Section of the Central Association of Science and Mathematics Teachers, November 27, 1903.

facts and classifying them as good, bad, and indifferent, but it also lacks the ability to seize upon the *salient* facts and to give them the prominence they deserve. Naturally related, but merely *qualifying* facts *must* be subordinate for the sake of a connected whole.

To illustrate, we may turn to the case of theme-writing. What the good teacher of English desires is not the apostrophes and rhapsodies that have in the past characterized the so-called "essay" of the high school student, but straightforward *paragraph* structure, each paragraph having some *one* salient idea, with qualifications properly subordinated. Anyone who has ever seen the average student attempt to write a connected account of an experiment will realize what a help the course in science work, properly conducted, may be to the English teacher. In an experiment in physics, for example, the teacher should not require that the student know all there is to be known about the physical phenomena involved, but that he shall observe certain conditions *carefully;* so that all the operations required in the experiment shall bring out *one* idea pertaining to the subject of the experiment.

This brings me to the second advantage of the single emphasis method, namely, the concentration of the instructor's guidance. How much it means to the instructor to be able to concentrate *his* attention will be apparent to anyone who has tried to teach all the sciences with, perhaps, mathematics, Latin and German thrown in, as has been the case with some of us. Now, precisely as the person who teaches only chemistry has a great advantage over one who must teach all the other sciences, so the teacher using the "one-point-emphasis" method has a great advantage over the one who permits or encourages his students to roam over the whole field of science at each experiment. The teacher demanding that a distinct idea shall be got out of each experiment, himself gets a distinct idea of the *possibilities* of each experiment as a piece of mental training.

The result of this concentration of emphasis on the part of both teacher and student will inevitably be that more and more of our students will know certain things *definitely.* You will remember that the Mosely commission, on its recent visit to this country, gave its opinion of educational work in our public schools

in these words: "Your students show a fine spirit, but not much in the way of distinct attainments." I take it that the "one-point-emphasis" method will prove to be the only way to get hold of these "attainments," or exact knowledge of a few things.

But it must be admitted that the method of putting emphasis upon a single point in an experiment and subordinating other naturally related phenomena has certain *disadvantages*. In the first place, the experimental work *may* become divided into fragments, leaving little idea of the connection between experiments. Again, unless great care is taken, methods of work become *mechanical*. Thus, the student of chemistry, intent only on getting a certain precipitate for study, makes a poor filter, and fails to observe many of the interesting phenomena of filtration. Again, the student of physics, while able to weigh an object accurately upon a balance, may have a very inadequate idea of the method of getting the *true* weight of the object under consideration. Then, too, it is not only the student who may become mechanical in his work, but the teacher as well. It is, unfortunately, not an impossibility to find teachers of physics and chemistry who, so long as their students get results which are fairly accurate, are largely indifferent to the greater region of phenomena of which the experiments done by the student form only a very insignificant part.

The process of *analysis*, or separation, of phenomena in science teaching has its converse in several *synthetic* operations now taking place. Thus, we find physics, geometry and arithmetic getting together in the subject of *mensuration*, for which arithmetic has hitherto given the rules, geometry the theory, and physics the practice. Again, all the sciences are getting together in a course of elementary general science, in which certain phenomena and laws of all the sciences are presented from a common point of view. Such syntheses can not fail to have their effect upon the experiments of the different sciences. Gradually we shall modify our purely quantitative laboratory work in physics so that more of the qualitative idea shall enter into its experiments; and, on the other hand, those sciences in the teaching of which quantitative experiments have as yet made little progress, will find it possible to introduce such experiments with good results.

The problem presented in our topic is, therefore, one which still invites discussion. I shall content myself with having stated some of its phases, and shall leave the finding of more specific conclusions for those that follow me.

A METHOD OF KEEPING LABORATORY NOTES.

BY FRANKLIN TURNER JONES,

Physics and Chemistry, University School, Cleveland.

In common with other teachers of physics and chemistry, the writer has contended with the problem of getting satisfactory notes in the physical and chemical laboratories. After trying almost every suggestion which came to his notice, a plan was finally devised which has proved so satisfactory that he ventures to put it into print for the consideration of others who may be looking for better methods of keeping notes. As far as the writer knows, no outline of a similar plan has thus far been published.

The note book used for some years is quadrille ruled in half-centimeter squares, with board covers, and containing about one hundred and twenty pages. It has been made up especially for the use of some of the Cleveland schools by the Union Paper & Twine Company, Cleveland, after specifications furnished by Mr. George R. Twiss, of the Central High School.

Left-hand pages have been reserved for notes taken in the laboratory—usually in pencil—and right-hand pages have been used for the write-up of the experiment under the usual formal headings—*Object, Method and Apparatus, Manipulation, Observations,* and *Conclusion.*

The work on left-hand pages was done during the laboratory period, while the write-up on right-hand pages was done outside the laboratory at the convenience of the student. In almost all

cases the work outside the laboratory was well and carefully done, but the quality of the original notes has always been more or less disappointing because it was impossible for the instructor to get around the class in time to see that all were making the proper notes. Then, too, the fact that those notes were not to be inspected until the books were handed in, allowed the careless an opportunity to put off the making of notes which they thought they could "just as well remember." The note books were not kept always in the laboratory, because it was desired that the work should be carefully reviewed and worked over in the write-up, and the laboratory periods are rarely long enough for this to be done with sufficient deliberation.

Evidently the weak point of the system was in the notes to be taken in laboratory. To remedy the defect, the following plan was devised: A carbon sheet about the same size ($5\frac{1}{2}''$x$8\frac{1}{2}''$) as the note-book page was furnished each pupil, also sheets of paper with margins punched for filing. On the loose sheet an exact transcript of every note taken in the laboratory was obtained. Erasure of an entry was found to be impossible, appearing as a smear on the loose sheet, thus compelling all data to be retained and rejected data to be properly marked. As soon as the experiment was completed, the loose sheet was handed in, and a glance, almost, would tell whether the data were of sufficient value to justify writing up. Any later change of observations could also be immediately detected by comparing the write-up with the transcript of the original.

The results of trials of this plan, both at South High School with large classes and at University School with small, have exceeded fondest expectations. The quality of the work obtained has been all that could be desired and far better and more complete than was ever obtained in the old way. Apparently, the stimulus has come from the immediate necessity of bringing the notes under the eye of the teacher.

A SIMPLE VOLUMENOMETER.

BY H. WIGLEY.

Municipal Technical School, Gravesend, England.

The writer has long felt the need of some simple apparatus that could be used by beginners in practical physics to determine the volumes of solids.

Such apparatus would be employed (1) to check calculations of volumes made from measurements; (2) to establish the ratio between the volumes of a cone, sphere, and cylinder of same heights and diameters; (3) to exemplify the "principle of Archimedes"; (4) to determine the specific gravity of solids, etc.

To this end overflow cans of various forms and sizes have been made and tried. In all cases the instrument has proved itself not sufficiently sensitive, and the results obtained have been irregular and inconsistent, so much so, in fact, as to quite destroy a student's confidence in his methods.

Experiments have since been made with apparatus, in which the "water displaced" by a solid can be removed by a siphon. After many forms had been tried and rejected, a simple one was hit upon which gave excellent results.

Before proceeding to describe the instrument in detail, the following rules may be laid down:

(1) The siphon must remain fixed relatively to the water-level in the can throughout an experiment.

(2) The siphon must not empty itself when the water inside the can falls below the level of its inner limb.

This latter result can be insured (1) by not allowing the difference in length between the limbs of the siphon to exceed 3 cm., and (2) by drawing out the ends of these limbs to a point.

FORM A (Fig. 1)—This consists of a water-tight can 10 cm. high by 5 cm. in diameter, to the edge of which a tubular "cork-holder" of tin or copper is strongly soldered. This should taper a little downwards, and be about 3 cm. long by 2 cm. diameter.

The siphon consists of two pieces of glass tubing 5 mm. in diameter, each bent at right angles once, and drawn out one end to a point. The shorter limb is passed through the cork in the

holder, and attached to the longer by an india-rubber connection. *The diagram indicates the positions of the parts.* The can itself may well be lined with a coating of paraffin wax.

To charge the siphon, fill the can till the point of the inner limb is covered and then draw the water through the tubes by suction. Place the can in the position in which it will be used, and allow the water to trickle out till it falls below the point A.

The addition of the object under experiment—lowered into

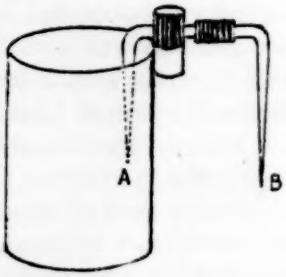

Fig. 1.

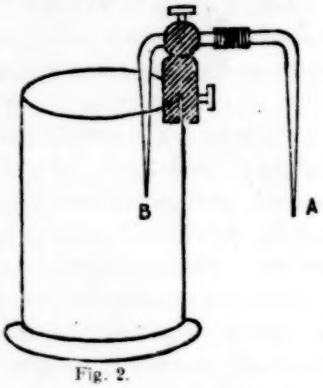

Fig. 2.

the can by a fine wire—will drive its own volume of water through the siphon. This may be allowed to run at once (*a*) into a wet burette and measured, or (*b*) into a wet evaporating dish, from which it was poured into a burette for measurement, or (*c*) into a tared beaker, when it may be weighed.

When once the siphon is full, the volumes of a series of small objects may be determined by adding them one after another to the can without removing any. In this way six estimations can be made in fifteen minutes.

Form B (Fig 2.)—This consists of a glass cylinder instead of a tin can, and the siphon-holder is an ordinary "zinc terminal" binding-screw, bored to take the glass tube. The hole must be parallel to, and in the same vertical plane with, that of the clamping-screw below.

It may be used in lieu of Form A with advantage, where expense is no object, but it was designed especially for determining the specific gravity of salts soluble in water.

In such determinations a saturated solution of the salt is first placed in the cylinder. The siphon is filled with water at the tap, or by suction, and then adjusted to the cylinder, while one finger is kept over the end of the exit tube. The solution is then allowed to run out till it falls below B. The addition of a weighed quantity of the salt will now displace its own volume of the solution, which is measured in a burette and charged with the same liquid. By dividing the weight of the salt in grams by the number of cubic centimeters displaced, the specific gravity is determined with great accuracy.

For volumes less than 2 cm.^{3} a narrower cylinder is desirable. This can also be used with advantage for the specific gravity of salts.

To show the accuracy of the instrument, results obtained in the Gravesend Municipal Day School are appended.

1. *Volumes.*

	Vol. found in cm.^{3}	Vol. calulated in cm.^{3}
Copper cylinder	8.0	8.042
100 gram weight	12.0	11.954
50 gram weight	6.0	.....
20 gram weight	2.4	.....
10 gram weight	1.2	.....

2. *Ratio between Cone, Sphere, and Cylinder.*

Water displaced by cone..... = 14.8 cm.^{3}
" " " sphere..... = 29.7 cm.^{3}
" " " cylinder..... = 44.5 cm.^{3}

3. *Principle of Archimedes.*

A 50 gram weight on a spring balance weighed 44.1 grams in the water of the can, and displaced 6.0 cm.^{3} of the water into a burette clamped beneath the delivery tube of the siphon.

4. *Specific Gravity of Salts.*

Salt.	Sp. gr. found.	Sp. gr. (Barley).
Potassium bichromate	2.59	2.6
Sodium chloride	2.16	2.16
Ferrous sulphate	1.96	1.97
Ammonium chloride	1.51	1.5
Sodium nitrate	2.28	2.26
Copper sulphate	2.12	2.3

NOTES ON RECENT ADVANCES IN ZOOLOGY.*

II.

BY MAURICE A. BIGELOW,
Department of Biology, Teachers' College, Columbia University.

Digestion in Isopods.—In line with recent views regarding digestion and absorption in higher animals are the results obtained from the experimental studies on isopod crustaceans by Dr. J. R. Murlin, working at the University of Pennsylvania. The secretions of the digestive glands of these animals act upon the three classes of foods represented by starches, fats and proteids. Eight hours after feeding raw beef, albumose granules were present in the intestinal epithelial cells, as demonstrated by microchemical tests. Preparations made later show that the granules move across the cells toward their cœlomic ends where absorption by circulating fluids must take place. But albumose has not been found in the circulatory fluids, and probably some intracellular ferment in the intestinal epithelial cells changes it to albumens before reaching the blood—a view fully in harmony with the now widely accepted theory regarding the absorption of peptones and albumoses in higher vertebrates.

Dr. Murlin's results on fat digestion and absorption are directly in line with the view, which recently has gained wide acceptance, that solution, and not emulsification, is the final stage of fat digestion and the beginning of its absorption in the small intestine of mammals. Eight or ten hours after feeding the sow-bugs with fats (butter, beef-suet) granules appear in the absorbing cells of the intestine. Numerous microchemical studies led to the conclusion that neutral fats are (1) split and dissociated in the intestinal cavity by the digestive secretions from the hepato-pancreas, (2) then absorbed by the epithelial cells as cleavage products in solution, (3) synthesized to neutral fat globules inside the cells, (4) then leave the cells for the circulatory fluids not as discrete fat particles, but probably as cleavage products in solution, and (5) finally appear in the blood as neutral fats. (Proc. Acad. Sci. Philadelphia, May, 1902, pp. 284-359.)

Carbonic Acid and Artificial Parthenogenesis.—Sea water charged with carbon dioxide is another addition to the already long list of chemical and physical agents capable of producing artificial parthenogenesis in starfish eggs. (Comptes Rendus, Tom. 135 (1902) p. 570.)

Ants and Ultra-Violet and Röntgen Rays.—Forel and Dufour give very convincing proof that ants react to ultra-violet rays, as stated by earlier workers. Apparently X-rays do not influence them. (Zoöl. Jahrb., XVII (1902) pp. 335-338.)

*The first installment of Notes is on page 102 of volume III.

"Liver" of Crayfish.—Experiments by H. Jordan and others indicate that the functions of the so-called "liver" of the European crayfish Astacus are formation of digestive juice and absorption of food. In short, the "liver" is from the functional point of view a vast increase of the mid-gut. (Verh. Deutsch. Zoöl. Ges. XII, Vers. (1902) pp. 183-186.)

According to other recent authors the organ has also an excretory function similar to that of the antennary kidney ("green gland") in all higher crustacea so far examined.

Colors of Fishes.—A very interesting paper by President Jordan, of Stanford University, discusses in a general way the coloration of fishes and its significance, especially in relation to the current theory of protective resemblance. (Amer. Nat., Vol. 36, pp. 803-8, Oct., 1902.)

Death-Feigning Amphipods.—Dr. S. J. Holmes, of the University of Michigan, suggests that the death-feigning instinct in sand-hoppers (Talorchestia) is a useful one in that when lying quietly on the sand these protectively colored animals are easily overlooked by their enemies.

Origin of the Paired Limbs of Vertebrates.—Professor Bashford, Dean of Columbia University, points out that the lateral-fold fins of the oldest Palæozoic sharks and evidence from an advancing series of later forms support the theory of the derivation of the paired limbs of vertebrates from continuous later skin-folds. (Amer. Nat. Vol. 36, pp. 767-776, Oct., 1902.)

Vascular System of Squid.—Of interest to teachers of zoölogy who may wish to re-examine the vascular system of the common squid for their personal information—of course few teachers now seriously think of such work for high school pupils—is a paper by Dr. L. W. Williams, of Brown University. (Amer. Nat., Vol. 37, Oct., 1902.)

Taste in Fishes.—Professor Herrick, of Denison University, concludes from many interesting experiments and studies of the nerve distributions that fishes having terminal buds located in the outer skin or on barblets, "feelers" or loose fin-rays, taste by means of these organs and may find their food by their means, while fishes which lack these organs in the skin have the sense of taste confined to the taste buds of the mouth. These and the terminal buds of the skin are related in structure and innervation, but no such relation exists between either of these and the organs of the lateral-line system. Summarizing the investigations of all recent authors, the skin of fishes appears to have (1) a tactile sense through the general cutaneous nerves, (2) maintenance of equilibrium and perception of mass motion of water by the lateral-line organs, and (3) a gustatory sense of the terminal organs, which are in some fishes found in all parts of the body surface, but in others apparently absent. (U. S. Fish Com. Bulletin for 1902, pp. 237-272.)

Hearing in Fishes.—Professor Parker, of Harvard, has made some

interesting experiments to test the old question whether fishes hear; that is, whether their ears are stimulated by sound waves. The first apparatus consisted of an aquarium with one end made of wood on the outside of which a bass viol string was stretched so that its vibrations would be transmitted through the sounding board into the water. Using this apparatus, even earless fishes reacted eighteen times in 100 trials, but there was evidence that the whole aquarium vibrated. In an improved apparatus made by substituting an electric tuning fork in place of the vibrating string, earless fishes never responded while normal ones usually did. The conclusion is that the killifish, with which the experiments were made, hears with its ears. However, the same methods failed to give evidence of hearing in a species of dogfish, and this suggests that the results of other investigators who have found no evidence of hearing may have been obtained from fishes in which the function is undeveloped. (Amer. Naturalist, Vol. 37, 1903.)

Phototropism of Frog.—Professor Parker has also been experimenting with the common leopard frog, and finds that it is positively phototropic to light from Nernst lamps with varying intensity from one to over 20,000 candle-meters. The frogs always turn toward the light and usually move in the same direction. The light receptive function appears to be in both skin and eyes, for reactions were obtained from eyeless frogs and from normal ones with skin covered. These results are in line with those of previous investigators who have found that the Proteus responds to light when the eyes are covered, and light induces reactions in blind fishes from the waves. (Amer. Jour. Phy., Vol. 10, Sept., 1903.)

Variation in Copepods.—How uncertain for systematic purposes are many of the details of structure, such as number of joints of appendages, upon which is based much of the classification of copepod species is suggested by Dr. Esther F. Byrnes, of the Girls' High School, Brooklyn, in a recent paper on the variation of copepods from Long Island (Biol. Bull., Vol. 5, Aug., 1903). She presents evidence pointing to the conclusion that forms of Cyclops with thirteen, fourteen and eighteen antennal joints are merely variations or immature stages of the seventeen-jointed species. Upon these minor differences several species have been based by authors. Other students of entomostracan crustacea have in recent years found similar variations, representing stages of life-history and induced by varying external conditions, and these must be carefully studied before there can be any approximation to a settled classification of these highly variable groups. Students of variation are surely doing great service to taxonomy by making investigators more cautious about establishing new species.

Metrology.*

THE METRIC SYSTEM PSYCHOLOGICALLY CONSIDERED.[1]

BY WILLIAM F. WHITE.

The metric system, being psychologically the only defensible system of measures to meet the important and growing needs of science and commerce, and having become already much more extensively used than any other and having the prospect of universal adoption, should, notwithstanding the temporary inconvenience of a change, be made compulsory in commerce in the United States, and should be taught in accordance with most approved psychological and pedagogical principles.

This thesis leads to the consideration of the following: (1) importance of measurement; (2) superiority of metric system; (3) history, extent of use, and prospects of metric system; (4) temporary inconvenience of change of system; (5) compulsory adoption of metric system in United States; (6) teaching of metric system.

IMPORTANCE OF MEASUREMENT.

"Scientific experiments in the highest sense of the word are made up of measurements."[2] "Lying at the base of all physical science is a great and complex science of Quantity,—the one indispensable Instrument by means of which Knowledge becomes Science (for Science is only quantitative knowledge)."[3]

The vast extent of modern industrial and commercial operations makes necessary the use of weight and measure[4] to an extent unparalleled in the past.

The importance of exact measurement and convenient comparison is shown by the establishment of a national bureau of standards in every great nation, and of an international bureau

[1]Colon abbreviations for most frequent forenames, compiled by C: A. Cutter and adopted by Am. Library Association, are used in the notes and the bibliography.

[2]Scripture, E. W. *New psychology*, London 1898, p. 72.

[3]Lewes, G: H: *Biographical history of philosophy*. N. Y., 1901, p. 159.

[4]It is customary to say "weight and measure," although weight is a measure—the measure of mass. Metrology has to do with the *measure* of length, area, capacity, mass, etc.

*Communications for the Department of Metrology should be sent to Rufus P. Williams, North Cambridge, Mass.

whose expense is borne by twenty-two nations; also by the pains taken by these bureaus to attain a high degree of accuracy in the relation between standards. A comparison of the meter and the imperial yard, made jointly by the international bureau and the standards office of Great Britain, gave the relation 1 meter = 39.370113 inches. This is the legal ratio in Great Britain. The United States defines the inch so that 39.37 inches are exactly equal to 1 meter. For the pound, the U. S. bureau of standards uses the value 453.5924277 grams.

No such care would have been taken, had not the needs of the laboratory and the workshop required it. The importance of measurement in modern life makes it in the highest degree desirable that the very best system be used.

SUPERIORITY OF THE METRIC SYSTEM.

The superiority of the metric system, psychologically, over any other system of weights and measures ever used, is conceded so universally as to need no proof. But some special points deserve consideration.

It has sometimes been said by advocates of some particular system of metrology that its units are of such magnitudes that the mind uses them more naturally than larger or smaller units, apart from the matter of familiarity with them. Psychologically there can be no such preference among units. If Weber's law holds—as in all probability it does approximately and within reasonable limits of application—then whatever part of any unit can be discriminated by the mind, that same part of any other unit can also be discriminated. The chief of the German bureau of weights and measures, writing in 1896 about the compulsory adoption of the metric system in that country in 1872-3, remarked: "In Germany people always said, 'The meter is so long, we can estimate by the foot but not by the meter' . . . Now, experience has shown that here too people have only hung a cloak around habit in order to hide its nakedness."[5]

The tendency of the mind to take things in rhythm may give to a system with a uniform scale an advantage over one with an irregular scale, on purely theoretic psychological grounds, independently of the more obvious considerations.

[5]Report from the committee on coinage, weights & measures, on H. R. 7251. Report no. 2885, 54th cong. 2d ses. p. 13.

The mind is much less likely to make a mistake in the use of a decimal system than in the use of such a "system" as the customary. The misplacing of the decimal point is an infrequent error: being so conspicuous an error, it is readily detected. This is shown in the use of the metric system in the commerce of many lands and in science everywhere, and in the use of decimal coinage in this country and elsewhere. It is in part the practical immunity from error which has led to the exclusive use of the metric system in the surgeon-general's department of the army and of the navy, and in the marine hospital service, and to its largely increasing use in the drug business of the country. At the time of the discussion in 1896 the state chemist of Georgia made the statement that "when one understands the metric system, he can hardly make a blunder with it, but with the system now in use here it is exceedingly doubtful if one out of ten average citizens really properly understands it."[6]

A strong psychological argument in favor of the metric system is the simplicity of its terms. The system being for universal use, the Greek and Latin languages being the common heritage of all modern peoples, and the prefixes chosen being comparatively few and simple and, for the most part, those that are used in words outside the metric system, the terms used are probably as expressive and as convenient as could be selected. In comparison with the multitude of unrelated terms used in the customary system, the terminology of the metric system is remarkably simple. Moreover, in almost any one occupation only one or two units of a table will be employed, all others being expressed in terms of these; thus today in units of length the optician uses only the millimeter (writing 20 mm, not 2 cm) while the librarian uses almost exclusively the centimeter. All the simplification desired in metric terminology can be had by omissions without affecting the system fundamentally or impairing its inherent advantages.

(To be Continued.)

Another Country Adopting the Metric System.—The New Zealand Houses of Parliament on July 28, 1903, passed a Weights and Measures Act, giving the governor power to proclaim that at any time after January 1, 1906, the metric system shall be the only system of weights and measures recognized in New Zealand.

R. P. W.

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[6] G. F. Payne in *Atlanta Journal*, March 21, 1896.

Metric Bill Before the House of Lords.—The Decimal Association of England has issued a circular in which it is stated: "It has been resolved early next session to introduce into the House of Lords a bill for the compulsory adoption of the metric weights and measures throughout the United Kingdom. The first reading of the bill will be moved by Lord Belhaven and seconded by Lord Kelvin, and such an encouraging amount of sympathy with this measure has been expressed privately by other peers, that there are good grounds for expecting that the second reading of the bill will be passed." As soon as the measure passes the House of Lords it will be brought before the Commons, and hope is expressed of its passage by both houses. R. P. W.

Thirty Important Questions Answered.—Bulletin No. 23, October, 1903, of the *American Chamber of Commerce,* 3 Rue Scribe, Paris, is devoted to the metric system. Questions were proposed by the Chamber covering the main points at issue in the adoption of the metric system, to the *Societé des Ingénieurs Civils de France,* at its meeting May 1, 1903, the proceedings being translated by L. V. Benèt, secretary of the Chamber. The discussion was participated in by quite a number of the members, to whom the system in all its details is as familiar as their own names, and was all favorable to the cause.

The fallacy of the contention so often made in the *Textile World Record* concerning the alleged inferiority of the metric system for the textile industry is shown, and further it is stated that the reason why there has not been complete uniformity in this industry is due in some cases to local causes and especially "to the fact that England, being predominant in the textile market, the French weavers are forced to employ the English system." The continued growth of the metric system for textile works in other countries than France is pointed out. One fact of that sort answers a score of statements that old customs do persist even in metric countries. French *savants* rightly regard arguments based solely on persistence of old measures as bordering on the ridiculous. Yet recent opposition literature in manufacturing industries is permeated with deductions from such unscholarly citations.

An interesting fact concerns the division of the circle, the decimalization of which, it has often been stated, has been abandoned. The reverse is true. M. Lallemand said: "The decimal division of angles is being adopted slowly but surely by the departments of government; the Navy, under the direction of Commandant Guyon, of *l'Institut,* and encouraged by the *Bureau des Longitudes,* has carried out long trials in this direction and has clearly demonstrated the advantage of the division of the circle into 400 *grades.* Astronomy alone, tied down by its traditions and by the forced retention of the day of twenty-four hours, appears to be constrained to continue for some time longer the old division of 360 degrees."

The careful student of metrology will find much of value in this pamphlet of thirty-one pages.

R. P. W.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

CHEMISTRY.

Melting Point of Manganese.—This was measured in an atmosphere of hydrogen in a specially designed electric furnace, and was found to be 1,245°.

Diffusion of Bromine Vapor in Hydrogen and in Air.—A few drops of bromine are placed by means of a pipette in the bottom of a glass cylinder about twenty-five cm. high. A large test tube filled with hydrogen by upward displacement is then without delay let down in the cylinder, and this covered with a glass plate. In a short time the bromine vapor will be seen to reach the upper end of the test tube, while outside the tube in the air the color of the halogen vapor will not appear half as high up.

Zeits. f. d. phys. u. chem. Unterricht, XV, p. 26. H. REHENSTORFF.

A Demonstration of the Presence of Phosphorus in Bone Ash.—In a hard glass tube closed at one end and about one cm. in diameter and twenty cm. long is placed a layer about three cm. high of powdered and well dried bone ash or apatite. About a third as much dry magnesium or aluminum powder is added. The tube is then heated very cautiously at first, but finally raised to a red heat, a large Bunsen or a blast flame being used. As soon as the reaction begins (shown by a flame and the incandescence of the mass) the tube is removed from the source of heat, at once tightly corked and set aside to cool.

In a darkened room the glow of the phosphorus which has been produced is readily seen. This can be made more vivid by rubbing the interior of the tube with a wire or by breaking off the upper end of the tube.

Zeits. f. d. phys. u. chem. Unterricht, XV, p. 96. M. MITTA.

Reports of Meetings.

PHYSICS CLUB OF NEW YORK.

The twenty-fourth meeting of the Club was held at the library of Columbia University Saturday, October 31, 1903.

Prof. Margaret E. Maltby, of Barnard College, presented a very suggestive paper on "The Practical Bearing of Physics on Chemistry."

Chairman Frank Rollins then presented the report of the Committee on College Entrance Examinations, recommending that

(*a*) "The examinations in physics be made somewhat more difficult from year to year; also, that a smaller number of optional questions be included in the paper set.

(*b*) That not more than 25 per cent of credit should be given to the notebook.

(*c*) For the examination of 1905 and thereafter the Board provide a laboratory examination in addition to the written examination." After much discussion by nearly all members of the club present it was voted to reject (*a*) and (*c*) of the Committee's report and to accept (*b*).

It was moved by Mr. Jameson that we recommend that the number of questions and alternatives be the same as heretofore, but that the questions of each group be more evenly balanced. This motion was carried.

It was moved by Mr. Arey that, as a partial substitute for the suggested laboratory examination which had not been recommended by the Club, one pair of the six pairs of questions be devoted to the laboratory experiments performed by the pupils. The motion prevailed.

Messrs. Gibson, Von Nardroff and Rollins then handed to each member present specimen pages of laboratory notebooks. The discussion of these, as also of the topic, "What a notebook should not contain," was postponed until the next meeting. After a report from Mr. Pierce for the Current Events Committee the Club adjourned for luncheon in the University Commons. After luncheon many members of the Club attended the afternoon session of the American Physical Society in Fayerweather Hall.

The twenty-fifth meeting of the Club was held at the Wadleigh High School, New York, on Saturday, December 19, 1903. The laboratories and science equipment of the school were open for inspection. This equipment consists of two combination laboratory and classrooms, two separate laboratories for physics, one chemical laboratory, one chemical recitation room, one physical lecture room, one chemical lecture room, a dark-

room, shop, office and four apparatus rooms. The lecture rooms and laboratories all have dark shades in addition to the ordinary shades. Each teacher's desk and each lecture table is equipped with water, gas and electricity. In one of the laboratories the apparatus for measuring resistance of wires was arranged; in another laboratory a device for illustracting the path of a projectile was shown. This consisted of a spring gun which was aimed at an angle of about 45° at a suspended ball, held in place by a magnet. The ball from the spring gun as it left the barrel broke an electric circuit and released the suspended ball, which fell. The falling ball and the ball shot from the gun collided in mid-air.

Mr. Albert Ball, for the Apparatus Committee, exhibited a set of lantern slides arranged by Mr. John C. Packard, of the Brookline (Mass.) High School, illustrative of the progress of electrical science. This set is sold by A. T. Thompson & Co., of 15 Tremont street, Boston. The report on Current Events in the Scientific World was presented in printed form by Mr. E. D. Pierce. This contained a carefully prepared list of the scientific articles which have appeared in current periodicals and scientific journals during the last year. Mr. Gibson read the criticisms which had been prepared by Mr. Jameson on the specimen forms of laboratory records which had been submitted by teachers in the various high schools. Mr. Ball stated what in his judgment a laboratory notebook should not contain as follows: (1) The book should not contain a formula which has not been proved; (2) it should not contain a copy of the direction sheets, but the student should state in clear and concise language what he did and what his conclusions were, and (3) no conclusion should state anything that has not been proved in the experiment itself.

Prof. Arthur Hopkins, of Amherst College, then delivered a carefully prepared paper on "The Practical Bearing of Chemistry on Physics."

After lunch had been served in the teachers' lunch room of the school, members of the Club visited the Waldorf-Astoria Hotel and inspected the electrical and heating appliances.

Reported by R. H. Cornish.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS—PHYSICS SECTION.

FRIDAY, NOVEMBER 27. 2:00 P. M.

The first number of the program was the presentation of "New Ideas in the Physics Laboratory and Lecture Room," by Mr. V. D. Hawkins, of the Joliet Township High School, Joliet, Ill. The first "idea" was a model of a device by which one is able to turn on and off an electric light by the use of wireless telegraphy. The second "idea" was a piece of apparatus for determining the index of refraction of water. The arrangement, though simple, yet permits students to make determina-

tions with an average error of 1 per cent. Both devices will be fully described in SCHOOL SCIENCE.

This was followed by an address, "Proper Fitting of Physics Pupils for Engineering Schools," by Dr. Carl Mees, president of the Rose Polytechnic Institute, Terre Haute, Ind.

President Mees laid great stress upon the pupil acquiring clear ideas of the fundamental principles of physics, especially in the subject of mechanics. The paper will be published in full in SCHOOL SCIENCE. In the discussion following Prof. R. A. Millikan, University of Chicago, laid emphasis upon the importance of wakening the pupil's interest in physics. Mr. F. R. Nichols, R. T. Crane Manual Training School, Chicago, emphasized the same point and also the importance of bringing illustrations from the pupil's daily life. Dr. C. R. Mann, University of Chicago, made clear the point that the paper outlined a course for pupils expecting to enter technical schools from the average high school and hence would not apply to the work in well equipped schools of the larger cities.

The discussion was followed by an address upon "Radium and Radio-Activity," by Dr. R. A. Millikan, assistant professor of physics, University of Chicago. This address gave a clear idea of the development of knowledge of radio-activity; of the phenomena accompanying this action; of the various substances exhibiting it; and of the latest theories and discoveries concerning it. A recess of twenty minutes was then taken to inspect apparatus brought by Professor Millikan for showing radium and its radio-activity.

After the recess a report of a committee on "Reference Books in Physics," was presented by the chairman, A. H. Sage, State Normal School, Oshkosh, Wis. The report indicated the importance of this work; showed what has been accomplished; and suggested the appointment of nine additional members of the committee to assist in preparing the complete report to be given next year. On motion the report and suggestions were adopted.

Copies of the preliminary report of the committee on "Questions for a Ten Days' Review of Physics," prepared by Mr. E. C. Woodruff, chairman, Lake View High School, Chicago, having been placed in the hands of the members of the section, consideration of the report was postponed till the Saturday meeting.

Mr. E. J. Andrews, Robert Waller High School, Chicago, showed a new controller for storage batteries by which any voltage from that of one cell to the capacity of the battery could readily be thrown into circuit.

SATURDAY, NOVEMBER 28, 9:00 A. M.

After consideration of the problems and topics presented by the committee on "Questions for a Ten Days' Review of Physics," the motion was made and carried that the preliminary report of the committee on Review Questions be accepted and that the committee, with the addi-

tion of five members, be continued. The committee to present at the next meeting a report with a list of problems suitable for secondary school work in physics.

The following officers were elected: Chairman, Willis E. Tower, Engelwood (Chicago) High School; vice-chairman, A. H. Sage, Oshkosh (Wis.) State Normal School; secretary, C. W. D. Parsons, Evanston (Ill.) Township High School.

The remainder of the time was taken up by an instructive discussion by Dr. Mees upon the report of the committee on Review Questions. On motion the section adjourned at 10:30 a. m. to attend the general session.

Reported by CHARLES W. D. PARSONS, Secretary.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATIC TEACHERS—EARTH SCIENCE SECTION.

On November 27, 1903, the section met in the dental lecture room of the Northwestern Professional Schools building. The chairman, Mr. Frank W. Darling, introduced Dr. Albert Perry Brigham, head of the Department of Natural History at Colgate University, who addressed the section on the subject of "Laboratory Work in Physical Geography." The address was followed by a laboratory exercise with topographic maps. Twenty minutes were devoted to the discussion of the principles underlying laboratory work.

Dr. John Paul Goode, Associate Professor of Geography at the University of Chicago, was the next speaker. He spoke upon the subject, "The Human Response to the Physical Environment."

Mr. L. L. Everly, of the R. T. Crane Manual Training High School, Chicago, reported upon "Current Topics of the Year."

On November 28 the section reassembled for a business meeting and general discussion. The following officers were elected for the ensuing year: Chairman, C. E. Peet, of Lewis Institute, Chicago; vice-chairman, Carrie M. Watson, Elgin (Ill.) High School; secretary, E. M. Williams, La Grange (Ill.) High School.

Mr. Smith, of the Elgin High School, offered a resolution which was adopted, as follows: *Resolved*, that it is the sense of this organization that field and laboratory work, so organized as to stimulate the self-activity of the individual pupils, is highly beneficial to the teaching of physical geography.

A discussion then followed on useful materials and books as aids in teaching geography. The members present furnished suggestions and

addresses for procuring suitable pictures, books, slides, speciments, etc. Some good suggestions for making simple experimental apparatus were offered, and it ended in the election of Mr. C. S. Jewell as a committee to report to the section, at its meeting in 1904, on pictures, maps, and the useful paraphernalia which could be obtained free of charge from various sources. Mr. Everly was elected as a committee to investigate and, if possible, make arrangements in the name of the section whereby the photographs of the United States Geological Survey might be made available for the teaching of physical geography.

In discussing the proper amount of time during the week which should be given to the subject of physical geography in high schools, it was determined by the section to use all individual influence possible to obtain six periods a week, two of which should be consecutive in one day for special laboratory work. Three periods to be used for general recitation work, and the remaining period each week to be an unprepared recitation for the general discussion of problems arising from laboratory work and the application of problems in physical geography into the every day life and experience of the pupils.

The papers as read on the first day's session follow:

LABORATORY WORK IN PHYSICAL GEOGRAPHY.

BY ALBERT PERRY BRIGHAM.

Practical exercises in physical geography may be called a novelty, and only a few well organized laboratories can yet be found, scattered here and there, as pioneers. Probably nowhere in the United States have so many schools taken this work vigorously in hand as in and about Chicago, and this is well shown in the very thorough and progressive laboratory manual about to be published under the editorship of a committee of Chicago teachers. Another sign of the times is in the work of the College Entrance Examination Board, which, beginning in 1902, now sets a regular examination in this subject. The number of candidates offering themselves is small, but is increasing, and the pertinent feature is that examinations are not accepted unless accompanied by notebooks, upon which 40 per cent of the count depends. Thus, the report to the Committee of Ten, the report of the Committee on College Entrance Requirements, and this work of the Examination Board may be regarded as more or less official recognitions of the progress of physical geography, as a subject capable of rational unfolding, through processes of actual experience which are as real and valuable as those used in other sciences.

Any real discussions of the laboratory must take account of the field, for here, theoretically, at least, is the most important sphere of actual work. It is under the open sky that we come into the presence of the real things. We can not vie with the chemist, the physicist and the

biologist in bringing the actual materials and forces into the laboratory that is roofed over. Hence arises the supreme importance of using well all that we can gain access to in the actual field.

No one is more keenly alive than I to the practical obstacles which hinder field work. How to get free days and half days, how to transport, safely and conveniently, classes of boys and girls, especially if they be large classes and in the city; how to combine attention with freedom; how to avoid undue expense, and allay the prejudices of the unintelligent—these are a few of the problems. Some might find a helpful hint in the method used at the high school in Joliet, of taking the noon lunch into the field and combining the noon hour with the first two periods of the afternoon, returning for the later periods. Others can command whole half-days, and all teachers can, by persistence, bring their principals or superintendents to an appreciation of the work, and make encouraging beginnings.

The types that can be found in any local environment are, as hinted above, limited in number. Stream work, however, is, in some form or other, one of the universal things. Weathering offers another group of changes and results that every teacher can find. Glacial phenomena are the common property of all who will recognize their heritage, in the Northern States. These are no small resources. Volcanoes and old lavas are not so common, though New England has its dikes and ancient lava sheets, and the Cordilleran region is full of such materials. Few places have such a combination of riches as Colorado Springs and Denver, with their easy assemblage of mountain and plain, desert and stream, gorge and snowfield, with rocks young and old, and the wide varieties of human relations thrown in with the wealth of nature.

But when we come to land forms on a large scale, marine plains, mountain systems, ocean shore lines—we are usually dependent on representative material, for we can not go far enough afield to find the things themselves. Happy is the teacher who has traveled and observed enough to have a store of types with which he can give reality to the maps, pictures and descriptions which must be the student's main reliance in his study.

The seasons, too, and unforseen changes of weather, interpose their peculiar difficulties, making it needful in the colder latitudes to crowd the out-of-door work into the weeks of the early autumn and two or three spring months. Many teachers will put down their own inexperience as the greatest difficulty of all. To all such the right advice is simple—learn to do field teaching by doing it. Go first to the locality yourself, question yourself about it, decide on the main points of instruction, and then plunge in. You can not fail, and your facility in the work will grow. You will see new things at each visit and the vitality of nature will be your helper.

The field exercise will involve a judicious combination of simple ex-

position and of questioning. As in all teaching, the student must, so far as possible, be put upon his own resources, so that he may genuinely see and think, and to this end carefully prepared reports of field work should be required.

But perhaps I am expected to speak more particularly of the equipment and work of the indoor laboratory. The first need here is a room set apart for the work. The recitation room is better than nothing and must often be used in lieu of something better, but it is wholly inadequate. The desks are too small to carry a quarter of the material which the student should often have before him. In rare cases the classroom may be large enough to admit of special tables on one or more sides, but this would afford only exceptional relief. No high school building should be erected without a spacious, well lighted room for a geographical laboratory. Its position should, if possible, favor the needs of meteorology. The one essential furnishing aside from the materials of actual study is a sufficient number of tables of any good laboratory pattern, such as would serve, for example, in biological work. There should be a drawer for each student. It goes without saying that there should be blackboards, and various devices for suspending mounted and unmounted maps. The materials may be stored in closets or in cases standing in the room. It is not designed in this brief paper to give the details of arrangement. The teacher who is privileged to organize such a laboratory should by all means examine the equipment at a university as Cornell, Harvard, or Chicago, where, with notebook in hand, and in conference with instructors, a large body of useful help can be gained in the shortest time. Also, an increasing number of high schools will afford useful models to the inquiring teacher.

When we come to the discussion of materials the field is wide. In beginning such work the question of expense is a vital one, and teachers will often be obliged to begin with an imperfect outfit. But, as in all subjects, faithful and effective use of little will prove the need of much. I think we must put maps first on the list. I do not now so much refer to the large maps, as of continents, that are essentials of the class exercise, as to the large scale maps, particularly the contoured maps of the United States Geological Survey. I am glad to see that the new Chicago Manual is making generous use of these. They are the cheapest modern material of high teaching value that is available, and duplicate sets for class exercises can be had by any school which can have anything. If necessary, they can be mounted by home work of teacher and students, so that they will stand the wear and tear of daily use. Ample directions for the selection and purchase of these have been given by Prof. W. M. Doris and others in papers and teachers' guides which are now accessible to all.

I should be inclined to make maps the central feature of indoor work, but would put no less emphasis on supplementing these with every kind of

visual and other representation that will make vivid and real the land forms and geographic conditions suggested by the map. Ultimately, models will take a large place in teaching, but there must first be more of them available, at smaller prices, and the scale of school appropriation must rise with a growing appreciation of geography. Therefore, we may now dismiss the subject with the scarcely needed advice, to get good models of the home region if you can, and others as rapidly as possible.

But there are two other sorts of material that we can have in reasonable abundance which will vastly aid in the study of maps, namely, pictures and descriptive literature. Many valuable subjects can be gleaned from the Perry pictures and from similar collections. Railroad and summer-resort pamphlets, illustrated papers and popular magazines will supply hundreds more, if the teacher has an eye to their value and will take the trouble to devise some simple scheme for storing and classifying them. This is labor, of course, and calls for warmth of interest, and for teachers who are not compelled to spread their work too widely. Teachers who have had actual experience in using pictures with maps in laboratory study would do well to communicate their results to their fellow instructors through school journals.

Photographs are more costly, but will accumulate, if they are sought by the instructors' and students' cameras, by donation, exchange and purchase. The vexing problem, also, of a typical collection of slides at moderate cost will some day be solved.

Nor is there any reason why a school should not have a modest outfit of minerals, common rocks, and of the mineral and botanical materials used in many common arts. It is not money so much as interest that is needed for the acquirement of such specimens.

If we inquire as to the proportion of time to be devoted to the several sub-topics, I can only say that my views have been elsewhere expressed and that the emphasis placed on the several kinds of practical exercises will be likely to correspond with the proportions observed in the textbook chosen, varying, of course, if the teacher is wise, with the laboratory material available and with the special knowledge of the teacher. For example, I should say that in general the lands should have much more time than the atmosphere, but an instructor versed in physics and meteorology, but ill prepared in physiography, should for the present at least teach most where he is most at home, to the neglect of ideal proportions. The seashore should not be given much time by most, but might require intensive study in Gloucester, Mass., or Norfolk, Va. Equally would the presence of your great lakes justify a similar emphasis. In short, laboratory work should be mixed with much common sense and will be a growth of years with any teacher and in any school. But if it be a growth, even the mistakes will have their place and teach some of the best lessons.

When we come to the arrangement of work as between the recitation

and the laboratory, much variety is inevitable for a long time to come, and perhaps always. Periods for recitation and double periods for the practical exercise would seem to be best. If double periods are not yet available, the single hour or even forty minutes will yield results. And where no formal laboratory work is organized, and but few duplicate maps or specimens are available, these should be used informally in periods and half periods in connection with the recitation.

The best equipped teachers may even dispense with exercises from a single text and use the lecture—recitation with supplementary reading, to advantage. Perhaps opinion would differ as to how far exposition and study of the text should precede or follow the laboratory exercise. Probably both are equally important. There is thus an enlightening introduction to the practical work, and there is the larger horizon opened to view by discussions based on observations. So far as a group can be engaged on the same piece of work, class instruction and questioning can go on in the laboratory, but the variable rates of progress by different pupils will often prevent this. Nor can laboratory and class work be always kept parallel, since some themes offer a larger body of exercises than others, and our equipment will be full in some topics and scanty in others. But all this is a minor matter, with vital instruction and strong interests aroused.

Work in the literature is an important supplement, particularly on the biological side and in bringing out the human and other organic relations of the physical facts about land and sea. Every variety of library work, reporting and essay preparation, that is possible in any subject of study is possible in geography.

THE HUMAN RESPONSE TO THE PHYSICAL ENVIRONMENT.

BY J. PAUL GOODE.

We think of man as living in an environment, the elements of which are largely the subject-matter of physical geography; and we are coming to realize that the true and complete geography is a study, not of physiography and the climate merely, but of the interaction between man and the physical part of his environment.

The term "environment" is so loosely used, and is made to include so much, that we must do some careful defining, to be sure of our ground, before taking up a discussion of our subject. The general conception of environment is the *not-me* which acts and reacts upon me. But this whole universe of forces and influences outside of myself is made up in part of the material world and its forces, and in part of the spiritual world and

its creations, which are quite as vital in determining my career as are many of the material considerations.

So our environment is to be analyzed in a dual way, as (1) physical, and (2) social, or sociological, as Herbert Spencer had it. Over a century ago Montesquieu, in his *Spirit of the Laws*, was fairly convinced of this analysis, and wrote so clearly and with such conviction as to the influence of the physical elements in our environment as to make himself one of the greatest contributors along this line, though he wrote before there was a science of geology, or physiography, or meteorology to furnish data or establish laws. And again about fifty years later Buckle, in his *History of Civilization*, made a wonderful statement of the significance of the purely physical elements in our social evolution, so good a presentation as to have been scarcely equaled since. And even in his time the modern science of geology was scarcely out of its swaddling clothes, and the sciences of meteorology and geography were not yet born.

Now that the tributary fields have been well worked, observations by millions made and recorded, and laws enunciated, we are able to arrive at a more complete and satisfactory analysis of our environment and make ourselves ready to recognize the effect of the fundamental physical elements.

Let me take up each of the phases of our environment and see its content and its bearing.

The *physical environment* has as its elements:

1. Climatic conditions—as hot or cold, arid or humid.
2. Land relief, or topography.
   a) Barriers—as mountain, or desert, or water.
   b) Character of surface—whether flat plain, or dissected plateau, or mountainous.
3. Soil—of increasing significance as time goes by.
4. Materials and forces available in a given region.
   a) Inorganic—as metals and minerals.
   b) Organic—plant and animal resources.
5. Competitors in the realm—whether human or the lower animals.

The *social environment* has for its sources and influences:

1. Psychic elements.
   The consciousness of kind (Giddings) giving rise to sympathy and coöperation in every stage of evolution from the lowest animal species to the highest conventions of modern society.
   The law of imitation (Tarde) is quite as sweeping in its application.
2. Economic relations.
   The pursuit of wealth the keynote of social impulse—Karl Marx, and later exploited by Dr. Patten. Herbert Spencer works along the same lines in his interpretation of our society as a progress from militarism to industrialism.

Progress under these influences is at first unconscious—as truly cosmic as the adaptation of a plant to a new environment. And in all our social organization, even in the highest phases, the purely cosmic, or unconscious, response to the forces in the environment is effective in larger meas-

ure than most people would willingly admit. We have but to look about us, and see the measure of heedless unthought with which we have exterminated certain noble animal species, as the bison and the seal; or see the ravenous haste with which we have wasted a continent's resource of forest, and the utterly reckless way in which we are ravishing the stored sunshine of past ages in our coal resource, to see that in very large measure we are as senseless and unconscious as the beasts of the field.

But though at first our evolution has been unconscious, and wholly the result of the chance geographic environment, sooner or later evolution becomes conscious and self-directed, and our noblest ideal for society is that it should become so in constantly larger measure. Lester F. Ward in his *Dynamic Sociology*, F. H. Giddings in his *Principles of Sociology*, and Benjamin Kidd in his *Social Evolution* all make much of this idea.

All these elements of environment express themselves in social institutions and conventions, which analyze themselves into a half-score of categories:

1. The organization of the family and the status of woman.
2. The idea of ownership in property.
3. Domestication of animals.
4. Agriculture.
5. Dress and adornment.
6. Shelter—leading to styles of architecture.
7. The use of metals.
8. The industrial arts—as in pottery, basketry, weaving, and the long list of mechanical inventions.
9. Forms of government—as military and industrial or economic.
10. Social forms and customs; beliefs, as superstitions, religions.

All these social conventions are in a large measure psychic, but all are secondary, or even tertiary. They are developed *after* they are initiated. All analyses of them come back to *initiation*. And the last analysis arrives at a purely psychological reaction—a nervous response to an external stimulus; that is, to living tissue acting on a physical environment. And so conditions favoring or inhibiting origins in all these lines are found in the "deal" (borrowing a term from whist) of the elements in the physical environment. The game that may be played, whether aggressive and brilliant, or passive and inert, depends very largely upon the cards held. And in the distribution of the elements of the physical environment, and the emphasis laid on each, every realm and age deals out a different combination.

The origins of social institutions, just as truly as the origins of changes in the living body of the plant or animal, are found in the conditions imposed by the physical environment, and ***progress depends upon a surplus***. This thought is most significant and far-reaching, and has been excellently presented by Dr. Simon N. Patten in his latest work, *Heredity and Social Progress*. The principle of the surplus must be kept in mind at every step in an analysis of the influence of the physical environment. It

is operative in the most primal phase of living tissue, and it applies at every stage in evolution up to the highest and most spiritual social institution. It will not be out of place to state briefly some of its principles:

1. A surplus of tissue in the cell gives opportunity for the occupation of more space. Hence a breaking up into multicellular structure and the differentiation of outer from inner tissue, and by an extension along this line of development, giving rise, in due time, to organs.

2. In the same way a surplus of energy in the individual man gives us the genius in one phase of development, and the liberal and iconoclast in another.

3. A surplus of energy in a social class impels to conquest, giving added power and leisure to the conqueror, making culture possible.[2]

I may add that a surplus of wants goes hand in hand with a surplus of wealth and leisure, to make progress continuous. Contentment is a mild name for decay. A protestant is a man with a conviction, plus a good backbone, and a stiff upper lip. For such a man laws are made—to be broken. Initiative comes from such men, and progress consists often in getting out of the rut.

The physical environment, then, is important in giving the conditions for initiative, and in furnishing the opportunity for a surplus; hence making for or against progress.

The highest point of view in geography is this very study of the physical environment in its influence on man's development, as furnishing the conditions in response to which changes may or must occur, (1) in the physical organism of man, and (2) in his social organization.

Now, changes in man's body are almost immeasurably slow. Notwithstanding the fact that our anthropoid ancestors began to abandon quadrupedal locomotion, it may be, over four million years ago, we are not yet wholly adapted in our bodies to an upright posture, as Brinton and others have shown. And the anatomists and physiologists enumerate 127 vestigial organs in our bodies—organs which are more or less useless now, but which functioned once, some of them dating back to an ancestor far less advanced than the *Pithecanthropus erectus* of Du Bois. We are familiar in our everyday life with many of these relics, such as the nictitating membrane of the eye and the vermiform appendix. It seems, as David Starr Jordan so wittily remarks, that the human body can never quite forget its past, but must carry around in itself perpetually the record of every stage in its physical evolution.

Our bodily response to the physical environment, then, is in many ways almost immeasurably slow. We may not yet name definitely the combinations in physical environment which give us color of skin, head form, peculiarities of hair structure, or cast of features. Yet we may

[2] See VEBLEN, *Theory of the Leisure Class*.

definitely say what conditions stunt the stature and inhibit action. The intelligent farmer or breeder is well assured of the principles along these lines, and the giant Norman Percheron horses are the demonstration of the law of surplus in the physical environment; and just as truly the stunted pony of Shetland and the cayuse of Montana answer for the lack of surplus. Professor Ripley, in his *Racial Geography of Europe,* makes a beautiful application of these principles in the discussion of the influences of the thin soil and the hard conditions in the Auvergne. The response is found direct, in the stunted, backward population, the miserable relic of a people pushed to the wall, in ages past, by more powerful tribes that came and evicted them from the rich and favored lower lands. And, again, that hard conditions dwarf stature may be shown in the study of the Jews. Downtrodden, persecuted, and narrowed in opportunities all over Europe, they have found in free and enlightened England an opportunity to take advantage of a surplus; and in the rich end of London, in the few generations they have been there, the average stature has been increased over an inch and a half. Edwin Markham's biting poem on "The Man with the Hoe" focuses our attention on the power of hard conditions to stunt and warp both body and mind.

Now, while the rate of change in man's body is for the most part so slow that, under the merely cosmic response to the physical environment, we must look for results to the effect of hundreds or thousands of years of its influence, on the other hand, changes in man's social organization are taking place under our very eyes. And though some of the social institutions are of as slow growth as many of the changes in man's body, yet the conditions of social organization are often found vitally fixed in the *ensemble* of the elements of the physical environment of a particular region. A people moving from a given region in which good measure of adaptation to the physical environment has been attained may find itself under the necessity of changing radically many of the social conventions to which it was accustomed, in order to survive. Of this we have record in almost numberless cases where frontiers have been passed by members of an old and static social order.

Such social adjustments, then, are relatively rapid, and there tends to be established a somewhat definite social order in a given type of geographic realm, which imposes itself upon almost any human stock which comes to occupy the region. Out of a dozen such type geographic regions which might be studied, let us choose one, and run rapidly over it, indicating briefly, as we may, the ways in which the physical environment reacts upon man, to limit, direct, and give character to his social state. In such a study of a type region the problem is to see how the elements of the physical environment determine social origins and shape their development. Let us take as a type region the arid area, and show the persistence of its influence in all the phases of social organization.

THE ARID AREA.

1. *The family and the status of woman.*—An arid plain in primitive society invites the chase. The animals of the realm are, in the first instance, of necessity herbivores. The scant grass and browse of such a plain calls for nimble deer, fleet of foot and ranging widely. To follow such a food supply, the family of the hunter must be ready to move rapidly and on short notice. This need reduces the family to its lowest terms—father, mother, child—and makes nomads of them of necessity. This life makes man the breadwinner and woman becomes a slave and chattel. Among the Amerind we have this shown in the Sioux, Apache, and other tribes of the great plains.

In such a region, if the animals are of such a nature as to be more useful living than dead, we come naturally to—

2. *The domestication of animals.*—With flocks and herds the food supply is less precarious, and the food capacity of the region is greater. The family unit becomes larger. Sons and grandsons may stay in the family group. This provides a larger measure of social culture; but the family is still under the whip of uncertain forage and of the need of migrations to pastures new. So social relations remain the same. We have the patriarch, and women are still inferior.

3. *Agriculture.*—With game scarce, the food supply is sought in plant life, and progress goes hand in hand with a domestication of plants. This locates the family along a river where water makes agriculture possible. In such a case women are, as a rule, the leaders, and become breadwinners equally with the men, or even superior to them. This means independence and power, and sooner or later social equality. With animals domesticated for draft, and milk as well, or meat, the food supply is made immensely more ample and more secure, and the home becomes static. The population becomes denser, and social customs, laws, and regulations become necessary. Here is the give-and-take of man to man which rubs off the rough corners and brings in time refinement and culture. In America the Pueblo Indians illustrate these influences in primitive society. In Egypt, Assyria, India, and China the earliest steps in civilization passed through these phases of development ages ago.

4. *The idea of ownership of property.*—On the arid plain individual property in *land* is unknown. It is so the world around. The ownership in the Russian steppe region, and many other similar regions in Asia, resides in the village, or the community. Our plains tribes have the very greatest difficulty in acquiring a notion of ownership in the land. It is as foreign to them as the ownership of air or sunshine to us. But where soil was from the start the source of bread, land is owned, and the thought of ownership is easy. It is well known that the private ownership of land is one of the foundation stones of our particular phase of civilization.

5. *Dress and personal adornment.*—The sub-arid plain and the pursuit of the deer restrict the material of dress almost wholly to skins. This is in itself a strong demand for simplicity of dress, and holds the dress ideal rather strictly to the law of utility. With the advent of a pastoral life, particularly with the possession of sheep, goats or camels, the availability of wool invites weaving, thus adding extensively to the variety and quality of the materials for dress. This is in itself a large invitation for advance in the arts of civilization. When agriculture comes in such a region, plant fibers increase the variety and the invitation for development. If the region is cold, at least for a good part of the year, this is a condition which holds an iron hand on the character of dress, and does not permit a wide departure from the fundamental law of utility. The trousers and the close-fitting garment owe their origin to such a physical condition. If the region is hot much of the year, the *need* of clothing is by so much reduced, and the institution of dress is more largely based on the purpose of adornment. The flowing robe, the skirt, and the shawl have their origin here.

In our western civilization we have inherited from both these sources. The conservative and leisure classes retain the display garments, and the workers keep style in dress much more close to the needs of the case. The court, the church, and female society still carry the garb of leisure and of low-latitude arid lands even into geographic environments where the retention of the style is a serious handicap and the occasion of much suffering. Here is a case of maladjustment to physical environment that flaunts itself in the face of the law of the survival of the fittest—a case where a social surplus is frittered away in useless friction with the physical environment, and energy is lost which might, if applied wisely, lift society and further civilization.

6. *Shelter—architecture.*—The need of rapid transit in following the deer reacts strongly upon the size and quality of the residence. Necessity requires a small shelter made of light material, which can be quickly taken down and moved and as quickly set up as need arises. The materials convenient for such purposes are poles and skins. So the tepee is a perfectly natural response to the conditions. All our tribes on the great plains had made almost a perfect adjustment along these lines when Europeans came. In the pastoral phase, woven stuff adds to variety of building materials, hence of the capacity of the abode, and so invites progress. The Tartar and Kurd have solved this problem.

When agriculture is established, the need for moving the abode does not arise. The dwelling becomes static, and so may be made of a larger variety of materials. The size is not limited nor the weight, so wood may enter more largely into construction, and as in arid lands even wood may not be plenty, sods and stones and baked clay become the building materials. So a massive construction is established because of the nature

of the most convenient materials. The sun's heat is the discomfort most necessary to counteract, hence the walls grow thick. There is little rain to be shed; so the roofs become flat, and a type of architecture is evolved. The Pueblos show us a primitive phase, the Egyptians a well differentiated style, and the Greeks a style which is perfection. But each one of them carries in every lineament the record of a climatic condition of origin. Contrast these styles of architecture of the arid land with the Gothic, which is an evolution of the tepee adapted to a humid clime.

7. *Use of metals.*—The presence or absence of metals in a realm has a powerful bearing on the social and economic possibilities of a people. The race very probably came to the use of the metals through finding native copper. There was a copper age, which grew gradually into a bronze age; and much later, with the accumulation of wisdom in metallurgy, iron came into use. But no people could come into the use of metal without having the metals to call on. They could have developed never so wisely in all lines, but without copper or iron they would have so serious a handicap as to make a high grade of culture out of the question. There are many coral isles in the Pacific with quite as high a culture as we could ask without the possession of the metals. Even after a high civilization is established the presence of coal and iron confers so powerful an advantage as to make their possessors great, willy nilly. Our Pueblos had the handicap of having no metals—a very serious bar against progress.

8. *Industrial arts and mechanical invention.*—Here again we are forced to see that the nature of the materials at hand shapes the possibilities in the way of progress in the long list of inventions. The origin of pottery seems closely connected with a life in arid conditions. Water is a prime necessity. It must be kept on hand. The skins of animals are convenient, but they are short-lived, and there are other obvious disadvantages. A basket lined with clay will hold water, and such a dish burned is pottery. In any case, the inventions which may be made depend upon the particular combination of the elements of the physical environment. The savage in England would make his bow of a single piece of yew. The Eskimo, lacking the yew, must use his wit, and get a compound bow of bone and sinew—a work of high art.

9. *Forms of government.*—The form of government grows out of the family organization and the way in which the daily bred is won. On the arid plain the strong hunter or the powerful warrior is chief. The whole life is one of the chase and the conquest of a weaker foe. It is not a long step from the hunting of the buffalo to the hunting of an enemy in the adjoining tribe. The arid realm breeds warriors and robbers—and might is right. In a pastoral society the family *is* the state, in origin, and the father is the head of the government; conditions are only slightly changed. Women are slaves and inferiors, and any evolution in government from such a foundation will end in the establishment of a hierarchy of rank,

with the strongest in the highest places. It is not different in any way from the rule of the barnyard among horned cattle. It is not a question of wisdom or right, but a question of brawn. Such a basis leads to the establishment of aristocracy, which, long planted and gone to seed, gives us the caste system in India. The culmination of all such government is the absolute monarchy, which is, in every instance, in last analysis, a military despotism.

Agriculture and the industrial arts tend to equality among workers, male and female. The tendency is to make the wise man the leader. The whole trend of such a foundation is toward democracy. Our Western civilization is in constant swing between these two great tendencies, the one of which we inherit from the arid Orient, the other from the agricultural lands of western Europe. And again, the Pueblos show us a primitive form of government, with the agricultural influence uppermost.

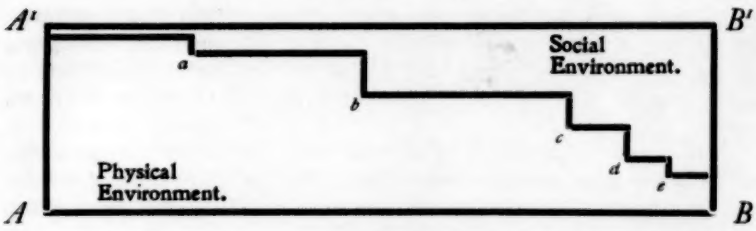
10. *Religion—social customs.*—The military organization dominates in religious establishment. In a military society the religious ideals are cast in the same mold. There is the same hierarchy, and every individual is given his station, with emphasis on obedience to the higher power. The supreme deity is the great war leader—the God of Hosts. We borrow this phase of our religion from the arid plains of the Orient. Even our hell and heaven are creations from the experiences born of a life in the hot desert and the delightful oasis.

But the practice of agriculture focuses the attention, not on a mighty conqueror, but upon the clouds. The crops depend upon the sun and the rain, and life and happiness depend upon the crops. Interest is focused on the return of the sun and the coming of the rain or the flood. This builds up a very different religion, which looks for the powers above us, in the sun and in the clouds and leads easily to the conception of the unknown god who rules the winds and brings the rains, and who lives in the sky. And these are elements found in the religion of every agricultural people settled in arid lands: Pueblo, Inca, Persian, Arabian, Hebrew.

RESUME.

Human development, physical and social, is, at the start, unconscious, a direct response to the conditions of the physical environment—a cosmic process. But the psychic, social element enters, and the experience of the race is gradually capitalized in the form of social institutions and conventions. These become forces competent to shape further progress, but they are clearly secondary, depending for initiation and for direction upon the conditions of the physical environment. Progress in social evolution is a record of a changing ratio between the influence of the physical environment and the power of this growing social environment. This changing ratio shows a growing independence of the physical environment on the part of man, even a domination over it. It may be represented graphically by a parallelogram, the length of which *AB*, stands

for the lapse of ages occupied by human evolution, and this may be four or five million years, if we may dare try to convert geological ages to years.



The ordinates AA', BB', represent in the terminal epochs the sum total of the forces in our environment, both physical and social, and may be most easily thought of in percentage up to 100, at the top line. With the *Homo alalus* the social environment was at a minimum, almost zero; the physical environment essentially 100 per cent. On the invention of language (*a*) a sudden access of social power makes a large conquest over the physical control. With the discovery of fire (*b*) another conquest over nature changes the ratio, reducing the control of the physical environment. Agriculture (*c*), domestication of beasts of burden (*d*), and every useful discovery or invention, mechanical or social, have changed the ratio, giving us added dominion over the elements of our physical environment. But we can never reduce this environment to zero. Be we never so wise and ingenious, we shall always be directed, and the course of our evolution will be conditioned by its elements. These forces may be unseen, but they are nevertheless potent, and they are eternal.

CURRENT EVENTS IN EARTH SCIENCE.

BY L. L. EVERLY.

IMPORTANT EVENTS—VOLCANOES.

In sharp contrast to the slow growth of volcanic cones by quiet eruptions, as in the long-observed volcanoes of Hawaii, Mt. Pelée has given to the scientific world an illustration of spasmodic growth in connection with her violent outbursts. In an article in the *American Journal of Science* of last month Mr. E. O. Hovey has given us a summary of the observations.

At the time of the first eruption, April 25, 1902, the rim of the old crater had an elevation of 2,296 feet. In one month, on May 31, it had risen 1,455 feet, and in another month, by June 29, 500 feet more, giving an elevation of 4,439 feet.

The following month a sharp fin began rising from near the top,

which, by October 15, had a height of 164 feet. During the eighteen days, November 8 to 26, 735 feet were added to its height, the fin then appearing, to observers using the telescope, to be a solid shining rock in the form of a lighthouse. By March 1 last it had lost more than half of this altitude by the splitting away of the material, but during the six days following March 3 it added 275 feet to its height and in another month 132 feet more, developing into the form of a church steeple.

The present cone which rises from one side of the former crater has no crater depression, but everywhere from its debris-covered surface issue clouds of incandescent rock and dust mingled with steam which roll down the sides as dry "dust flows."

SOILS.

The experiments carried on by the government to determine the relation between soils, air, bacteria and plants have met with partial success. After differentiating the bacteria that develop the nitrogenous nodules on the roots of leguminous plants, a test was applied as follows: Three lots of clean, sterilized, sand were taken, in one of which saltpeter was placed, and in another some cultured bacteria. Beans were planted in all three and watered with sterilized water. The beans sprouted in all three, but those in the box containing only sterilized sand soon faded and died; those feeding on saltpeter grew as ordinary plants grow, while those in the sand containing bacteria showed a marvelous growth.

From the government laboratories supplies of bacteria are furnished to farmers who will attempt to raise a crop hitherto impossible of cheap cultivation in that region. It is believed that thus alfalfa can be profitably grown east of the Missouri River—a fact hitherto impossible.

Another method of caring for the soil is just taking shape through the invention of Messrs. Bradley and Lovejoy. They have provided a hollow metal box inside of which, from a hundred sparking points, electric flashes are constantly given off. A 10,000-volt direct current developed at Niagara Falls is employed. The nitrogen and oxygen of the air in the box become combined into the oxides of nitrogen just as they are by the lightning's flash. These oxides are allowed to act upon caustic soda, producing Chile saltpeter. The cheapness of the production, one-fourth that of other processes, together with the rapid consumption of the natural supply of this valuable fertilizer, makes this invention one of great importance.

THREE OTHER MATTERS OF INTEREST.

First—A new factor in the commercial geography of the Great Lakes has been introduced by the people of the state of New York voting the expenditure of $100,000,000 to deepen the New York and Erie canal to a 14-foot channel, thus stimulating the shipping interests of our nation.

Second—Investigations carried on in the new deep shaft of the Calumet-Hekla copper mine for the past eighteen months indicate that earth temperatures increase 1° for every 110 feet, or one-half the rate stated in our present textbooks.

Third—A new chapter in the exploration of the upper air has begun by equipping some ocean-going steamers with kites provided with automatically-recording meteorological instruments (especially along the coasts of Scotland and within the trade-wind belt), while kites have been flown daily from Berlin and Hamburg. The altitude reached has been from 7,000 to 14,000 feet. The last number of SCIENCE states that among the results arrived at are:

1st.—That the height of the monsoon irregularities disappear at the elevation of the intermediate clouds.

2nd.—That the present statement of the circulation of the air between the tropics and the poles (Ferrells) must be abandoned.

MAGAZINE ARTICLES OF A THEORETICAL NATURE.

ORIGIN OF BOLSON PLAINS.

In the current number of the *American Journal of Science,* Mr. C. R. Keyes suggests a new origin for the bolson plains met with so frequently in the inter-montaine basins in the arid Southwest. After stating that the present theory of their lacustrine origin is untenable because of the lack of wave-cut terraces, he shows they are probably due to the occasional floods, bringing debris from the mountains, spread across the basin, distributing their sediment in the form of a lacustrine deposit.

ORIGIN OF CORAL REEFS.

In the September number of the same journal, Mr. J. Stanley Gardiner from his eight years of observations of coral reefs in the Indian Ocean states a partially new theory concerning them. He states that the facts of the last twenty years conclusively show that barrier reefs and atolls formed by the subsidence of the land around which they formed a fringe are exceedingly rare. Instead the general base of an atoll region seems to be a worn-down volcano or former land area, or accretions of remains of organisms in shallower parts of the sea. Reef-building corals do not live below thirty fathoms in such abundance as to form a reef. Wave action would cut down land areas to some 200 fathoms, then holozoic animals would build up to seventy-five fathoms. Then median-depth corals, not reef-builders, together with mollusca—especially Lithothamnion—would build up to twenty-five fathoms. The increase of light seems to be a barrier to these forms and hence from this point the true reef-building corals, feeding on their commensal algae build to the surface. Drift currents across a submarine plateau would inevitably divide into separate currents on account of the inequalities of

upward growth. Along these currents the corals would grow most rapidly, forming rims which would finally shut off food supplies from the areas between them. Then solution would proceed more rapidly in the central part, producing enclosed basins.

By absolutely cleaning away the corals from a certain spot and revisiting the place two or three years later it was proven corals could grow nine to fifteen feet per century, as opposed to the former view of one foot per century.

BOOKS PUBLISHED.

Last year witnessed the appearance of three new textbooks by Gilbert and Brigham, Davis, and by Dryer. These were followed this year by two accompanying teachers' guides, one for the Gilbert and Brigham text and one for the Davis text. Both of these furnish many valuable suggestions concerning the preparation of the teacher and the equipment of the laboratory, giving, in order, methods of presenting the various subjects by experiments, demonstrations, mapwork and book references.

Within a few weeks has appeared a volume entitled "Geographic Influences on American History" from the pen of Dr. Brigham. This volume combines materials of history and geography on a geographic basis. The discussion deals in turn with regions more or less distinct in physical form, but which often show a good measure of historical unity. The book is well illustrated with pictures and maps, and supplies a long felt want in a most thorough and delightful manner.

A volume on a similar subject, namely, "American History and Its Geographic Conditions," has also just appeared from the pen of Ellen Churchill Semple. Though not well illustrated, yet the abundant statistics and the detailed references at the end of each chapter make it a very valuable volume for the student.

Two similar volumes are now in course of preparation concerning Europe.

The new (fifth) edition of Le Conte's Geology makes one notable departure in stating that in the light of present day science the old theory of La Place concerning the origin of the earth can not longer be entertained; but that the planetesimal hypothesis as presented by Dr. T. C. Chamberlin is the most satisfactory statement at present.

ERRATUM.

Through an oversight, the paragraph on "Basket Ball" on page 365 of the December number was not credited as it should have been to *The Leader*, of Providence, R. I., for October, where it appeared on the editorial page.